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The Completion of Hopkinson's Famous Paper. THE electrical fraternity will be pleased to see that the now famous paper by Drs. J. and E. H. Hopkinson on dynamo-electric machinery, read and published in 1886, is at last completed, after a lapse of six years. The object of this paper, which we publish in another column, is to verify by experiment theoretical results which are given in the first part.

Compound Winding in England. THE English courts have finally settled the compound winding case, and this invention is now public property there. The English Brush Company who claimed the right by virtue of the famous Brush teaser patent of Nov. 16, 1878, charged royalties on all compound machines sold in England. A bold Scotch firm—King, Brown & Co.—refused to pay it, and brought the matter before the courts, which suit they have just won. The chief anticipation claimed was the patent of S. A. Varley, of 1876, in which a somewhat similar arrangement was described. It appears that neither of the two inventors knew the importance of the invention in the sense of the compound winding as used to-day. It is another one of those numerous annoying cases in which words and drawings accidentally appear to cover things which the inventor did not really invent. Meanwhile we in America continue to make compound machines without regard for any patent.

The Use of the Soap Bubble in Experimenting. THE ordinary commonplace soap bubble, which is generally looked upon as a mere plaything, is, in the hands of the physicist, not only an exceedingly interesting and instructive illustration of a number of phenomena, but it serves also as a sort of tool or apparatus for experimenting, and as such it apparently stands alone as one of the toughest and most elastic membranes known. That it is tough will doubtless at first appear strange to many because a bubble bursts so readily, but when its exceedingly small thickness is considered in connection with its relatively great tensile strength, it will be found to be well entitled to be called a tough membrane. Among the more recent applications of the soap bubble as a scientific tool in electrical researches are a series of experiments by Mr. C. V. Boys described in another column. They serve to show how the study of certain electrical and magnetic phenomena may be made very easy by the use of this delicate membrane. The experiments shown are not only of interest by themselves, but they may also suggest the employment of this cheap tool for investigating other electric and magnetic phenomena. The effect which electrification has on increasing the tendency for two films to unite, may aid in explaining some of the phenomena in a thunder storm, in which the conditions are in many respects quite similar.

The Same Old Story of European Anticipation. NOW as the first interest in the Tesla experiments abroad is subsiding somewhat, the inevitable European anticipator crops up in various forms. Now that they know what Tesla has done they know apparently for the first time what some old experimenter did, who, perhaps, did not know himself what he was doing at the time. We are now, however, quite accustomed to the stereotyped expressions from some of our English cousins, but they do not annoy us; on the contrary, they amuse us more than many of their jokes in their comic papers. Some English electrician states that the results can be obtained with Ruhmkorff coils and that the experiments are therefore less interesting. Others again say that the same thing was done before, but on a small scale, and that Tesla does it only on the large, liberal American scale. Mr. Wimshurst caps the climax by saying that he fails to see very much, if any more, than a great expenditure of money and energy. It is a satisfaction to know, however, that such expressions are not universal among Englishmen and that there are many who recognize and have the courage to admit it, that America occasionally does bring out something new in the electrical line. But these European anticipators seem to forget, if they ever knew it, that an American electrician called Benjamin Franklin was really the first one to experiment with alternating currents of high frequency and excessively high potential in June of the year 1752, when he bottled lightning. Fortunately for Tesla, this, like the English experiments, does not invalidate his patents and therefore is not a real anticipation.

Current Required for Incandescent Lamps. WE receive many inquiries from correspondents asking what currents incandescent lamps of certain voltages will take. In some respects this question is like the one asking what the size of a stone is. The best reply we can give to them, and the only really satisfactory way to get a fair average, is to place a number of these lamps, say 10 or 100, on a circuit and measure the current with an ampère meter, first being sure, however, that the electromotive force is the right amount. A good voltmeter and ammeter are therefore required. To ask the lamp sellers appears to be of little use, and would probably be unsatisfactory, as they will either not reply at all or give an evasive answer, or if they give any figure it is apt to be lower than the true amount, which overestimating of efficiency seems to be considered a manufacturer's license. A very good custom which seems to be growing among lamp manufacturers is the rating of lamps by their efficiency in watts per candle and whenever such figures can be obtained the current required by a lamp is very easily calculated. The usual efficiency is about four watts per candle, which multiplied by the alleged candle power and divided by the stated voltage will give the current in ampères. As lamps may be ordered for a given efficiency, this figure may be relied upon to a certain extent, as it is then accompanied by a sort of guarantee on the part of the makers. The Edison company makes lamps of 3.1, 3.6 and 4 watts per candle. The Thomson-Houston lamps are for 3.32, 3.5 and 4 watts for 52, 75 and 100-110 volts respectively. The Economic company's lamps are for 3.6 watts, and the Germania for 4 watts. The lower this figure the more economical the lamp will be, but in general the shorter the life. Low volt lamps as a rule use less watts per candle than those of high voltage, for the same life. The wireman will be safe if he assumes the larger figure, namely, four, as his wires will then at east not be too small. With these figures, provided the lamps really have the alleged candle power, any one can calculate the current required without writing to us.

Dangers of Steam Railroads. AT PRESENT the daily papers, aided by the people who object to the introduction of anything new on general principles, are gathering together all the objections they can find against trolley railways, and as each of the series of mouthpieces which transmit such reports transforms and amplifies them, their final forms often contain but a germ of truth, if that. I might be well to take a lesson from this for future use in other cases. The prospect of our principal steam railroads being converted into electric roads is growing every day, and it is not unlikely that in the near future we may be able to enjoy the pleasure of safe and reliable rapid transit between cities. Work is already under way and, as in the case of electric street railways, if a few roads prove to be a success, others will doubtless follow in very rapid succession. In view of this, it might be well for the electrical companies who contemplate at some future day having a siege with the newspapers and the public to begin to collect ammunition in the form of records of steam railroad accidents and their causes. Such records are sadly numerous at present; almost every issue of our daily papers will contribute something. The chief causes may be summed up as follows: Collisions inability to see signals, or neglect to obey them; explosions of locomotive boilers, breaking of reciprocating parts of the locomotive, fires started by sparks from the locomotive, breaking of bridges and derailment. All of these causes, except the last two, would not exist in a well built electric road from the very nature of the system. An electric road can be so arranged that a dead section of track precedes and follows each car or train, thereby rendering collisions impossible, as two trains could not meet each other except possibly on long down grades. Track signals and obedience to them will not be so necessary, as a train may be controlled (automatically if desired) entirely from stationary controlling stations. The other three causes evidently cannot exist in an electric system. As to the breaking of bridges the cause is often due to the powerful hammer blows of the reciprocating parts, and as such reciprocating parts do not exist in electric motors, this source of accidents is also reduced. There remains only the danger due to derailment; but as this is itself due, to a great extent, to the powerful oscillations produced by the reciprocating parts, even this source of danger is also reduced somewhat on electric roads. But even omitting the last two causes, it would probably not be any exaggeration to say, that by the substitution of electric for steam locomotives fully nine-tenths of the present sources of danger could be removed, in addition to which trains could be run more rapidly, at more frequent intervals and perhaps at less cost.

Questioning the Validity of Ohm's Law. FROM the opinions of prominent English electricians published in another column, it might at first appear as though there were great differences of opinion as to whether Ohm's law applies to alternating currents of high frequency and high potential. Some say very definitely that it does, while others, equally prominent, say as decidedly that it does not. Amateur theorizers and others who possess a dangerously small amount of knowledge on the subject, and whose desire to impart their knowledge to others is greater than their desire to acquire knowledge, might make much of this by claiming that the validity of Ohm's law, the very foundation of electrical science, is being shaken, and that this therefore enables them to introduce new theories of their own. We do not doubt that the real views of these prominent parties agree, although the statements of their opinions seem to disagree. Had the question been put in a different way the answers as to Ohm's law would doubtless have been practically alike. An intelligent consideration of these opinions will show that there need be no alarm as yet regarding the validity of our fundamental law, which after all is nothing more than a relation between an effect and its cause. If in any case it does not appear to apply it would be safer to assume that we do not know how to apply it rather than to blame the law for the apparent discrepancy. In electrolysis, arc lamps, charging accumulators, running motors, or in any case in which there is a counter electromotive force in the circuit, Ohm's law might be said to fail for even continuous currents if we did not take into account this counter electromotive force. But it must be remembered that in Ohm's law the E represents all the electromotive forces in the circuit, that is, their algebraic sum; if, therefore, there is an opposing electromotive force, whose sign is then minus, it must be subtracted before we can apply Ohm's law at all. In alternating current work such opposing electromotive forces are the rule and are therefore of great importance in applying the law. It should also be remembered that the resistance of some bodies may not follow the usual law of resistance; in some cases it already appears to be quite certain that it does not. We must therefore be very careful how we introduce the value of R in Ohm's law before we blame that law for any apparent failure. High frequencies and excessively high potential alternating currents seem to show us that there exist properties of bodies and currents which need not be considered in connection with the usual currents, but which are perhaps the most important to consider in dealing with these unusual currents. It will probably be safer to start with the assumption that Ohm's law is correct and proceed to investigate the E's, the R's and the C's rather than to assume that we know all about the latter and therefore condemn the law.

The Living Dynamo.

BY OLIVER WENDELL HOLMES.

(In honor of the 70th birthday of Edward Everett Hale.)

Night after night the incandescent arc
Has fought its dazzling battle with the dark,
Our doubtful paths with purest ray illumed,
Untired, undimmed, unswerving, unconsumed.

A slender wire the living light conveys
That startles midnight with its noonday blaze.
Through that same channel streams the giant force
That whirls the wheels along their clanking course
When, like a mail-clad monster, o'er the plain,
With clash and clamor sweeps the broomstick train.

Whence gains the wondrous wire its twofold dower,
Its double heritage of light and power?
Ask of the motor-man,—he ought to know,—
And he will tell you "from the dynamo."
And what, again, the dynamo inspires?
"A mighty engine, urged by quickening fires."

When I behold that large untiring brain
Which seventy winters have assailed in vain
Toiling, still toiling at its endless task,
With patience such as Sisyphus might ask,
To flood the paths of ignorance with light,
To speed the progress of the struggling right,
Its burning pulses borrowed from a heart
That claims in every grief a brother's part,
My lips repeat with reverence "Even so—
This is in truth a living Dynamo!"

Be ours to heed its lessons while we may,
Look up for light to guide our devious way—
Look forward bravely, look not weakly back,
The past is done with, mind the coming track;
Look in with searching eye and courage stout,
But when temptation comes look out! Look out!

Heaven grant all blessings time and earth can give
To him whose life has taught us how to live
Till on the golden dial of the spheres
The twentieth century counts its gathering years,
While many a birthday tells its cheerful tale,
And the round hundredth shouts, All hail! All hail!

Relative Weights and Cost of Dynamos.

BY CARL HERING.

The building of dynamos has now advanced to a sufficiently high degree of perfection that we may safely assume those of the most prominent makers to have approximately their best proportions. We may also assume that the selling prices, after having oscillated, have now assumed a nearly normal value. The outputs, weights and prices of a series of similar machines built by the same makers and of the same general design enable us, therefore, to obtain approximately, at least, an empirical law of the relative rates of increase of the weights and prices with the output. The law of the increase of weight with the output has been determined theoretically by a number of writers, but we do not believe that the empirically determined results have ever been published.

In order to give a general idea of these, a list of a series

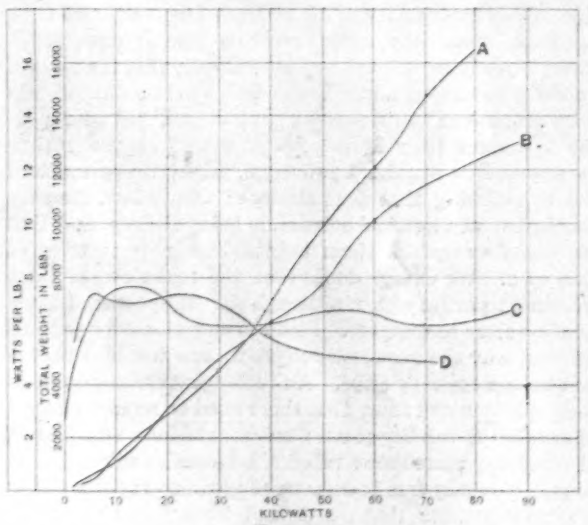


FIG. 1.

of similar machines was obtained from two of our prominent manufacturers, giving the output, weights and prices, from which the accompanying curves have been plotted. There were 15 machines in one series and 13 in the other. The dynamos in each case were all nearly alike in their relative dimensions, in one of them the drawings of the different machines even looked almost like photographic reductions.

In Fig. 1, curves *A* and *B* show the relation of the weight to the output in kilowatts. Both show that the output increases in almost direct proportion with the weight, and therefore approximately with the volumes or the cube of the dimensions. The fact that they are not quite straight lines shows that the machines are not quite correctly proportioned, or that the speeds do not diminish according to a regular law. The curves are, however, sufficiently straight to indicate a straight line proportion.

Curves *C* and *D* show the watts per pound obtained in the different sizes of the machines. They are not as regular, as there are greater variations among the smaller machines which do not show on the other curves. It will be seen, however, that with the exception of the parts representing the smaller sizes, the general direction of the curves approximates a straight line, which is slightly inclined to the horizontal, tending to approach it as the output becomes greater. It will be seen from these curves that for machines for more than 10 kilowatts about seven watts per pound may be assumed as a rough approximation for a very wide range of outputs. Curve *D* belongs to the same set of machines as *A*, while *C* belongs to the same as *B*. Of the two series it appears that in the one represented by *A* and *D* the relative proportions are the most regular.

Fig. 2 shows the relation of the selling (list) price and output. *A* and *B* show how the total selling price varies with the output. As in Fig. 1, *A* and *B* are practically straight lines, indicating, therefore, that the total price is nearly proportional to the output. Curve *A*, Fig. 2, is for the same series as *B* and *C* in Fig. 1, while *B* corresponds to *A* and *D*, Fig. 1. Curves *C* and *D*, which give the relation between the selling price per kilowatt and the output, show

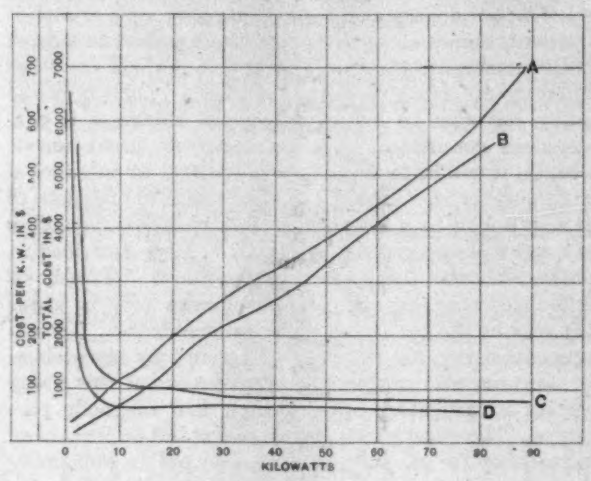


FIG. 2.

the very rapid increase for small machines, and the gradual decrease for large machines. From these it will be seen that for dynamos of over 10 kilowatts about $75 to $100 per kilowatt may be assumed as a rough approximation for quite a wide range. Curves *A* and *C* belong to one series, while *B* and *D* belong to the other. The cost of the dynamos plotted here is the list price, and is therefore in general subject to a discount.

If dynamo makers were to plot the data of their machines in this manner the irregularity of the curves would point out to them which machines are faulty in their proportions.

All the dynamos of these two series are two-pole incandescent light machines of about 120 to 130 volts.

New Uses of Small Incandescent Lamps.

Improvements in the methods of electric lighting and changes in their adaptation are now being made very rapidly. The old and fast disappearing illuminant which our fathers considered as the *ultima thule* of lighting has been put to many and varied uses, but they are as nothing when compared with the multifold duties which electric incandescent illumination has been called upon to fulfill. The character of electric illumination is fast changing. Instead of the large 16 c. p. lamp we can now have a number of smaller lamps of varying intensity so distributed as to give the same amount of light but more diffuse and agreeable and less obtrusive.

This change the Edison General Electric Company has not been slow to recognize. In its lamp works at Harrison experiments have been under way for the past six or eight months, all pointing to the invention and perfection of smaller lamps, which could appropriately be used for almost all requirements. The uses to which these small lamps can be put are too numerous to mention. Socketed in a wall bracket at the top of an imitation candle they simulate the flame of the wax light highly intensified. Studded in numbers in the ceiling of some spacious ballroom they diffuse a soft radiance unattainable by any other means, or they can be concealed in flowers and under eaves in a table piece with exquisite effect.

Those who have not carefully observed the effect of a liberal subdivision of the lights used in the various classes of indoor illumination would be surprised to find how much more advantageously the light may be distributed by the use of a large number of small units in preference to one, two or more lamps of large candle power.

Their purely commercial adaptation will, however, appeal most strongly to the practical man. The retail storekeeper desires some sign characteristic of his business. It can be artistically devised, and the little incandescents flashing from it will give it a value of peculiar attraction. These small lamps can be grouped to form any letters of any size or shape in any colors. By the aid of a special switch actuated by electricity or otherwise, they can be made to flash and die out alternately at fixed intervals, or all can be flashed at a time.

The Actors' Fund Fair at Madison Square Garden, in this city, will afford electricians the first opportunity of beholding and appreciating the progress that has been made in this direction. The entire illumination of the fair and the booths has been confided to the Edison General Electric Company, in so far as the lamps and special designs and apparatus are concerned, and every lighting effect produced will be absolutely novel. Each stand will be especially illuminated by means of the beautiful small lamps, and among the wonders of the Fair the great electric decorative illumination will be, perhaps, the greatest and most worthy of attention.

A Comparative Test of High and Low Speed Engines for Use in Electric Railway Power Plants.*

BY CHAS. W. WASON.

In making this second test I have endeavored to eliminate some of the causes of error that were apparent in my first test. By means of a simple device gotten up and applied by our electrician, Mr. Robert M. Fuller, to hold the pointers of the ampère meters simultaneously with the sounding of the bell, the men were enabled to get the exact reading at each interval. By a simple arrangement of slips upon which the readings were taken the electrical horse power of any reading of the ten hours is at once obtained.

In the test of the slow speed plant I endeavored to secure the mechanical horse power of the two Corliss engines by means of indicator cards taken at the same instant every fifteen minutes. I am indebted to Mr. P. A. Patterson, our engineer, for a very accurate calculation of them. From my slips I obtained the electrical horse power at the same instant, the average of the result being given below.

In order to find the dead load, owing to friction in engines, countershaft and generators, I ran the engines, countershaft and two generators with the third and fourth as motors, with the result as here shown. I then got the friction load of each engine with the other engine, countershaft and generators. This is also here given.

The number of passengers carried on each of these days and the number of car miles made are practically the same, so that in this test the "misleading" element, thought by some to exist in the former, will not present itself here.

There is a larger difference in coal consumed in favor of the slow speed than in the first test, but still it is not what I expected it would show. I have been an advocate of slow speed engines for railroad work, but the results obtained from these tests caused me to doubt whether my position is tenable.

The following are the results of the test:

For the report of the first test see THE ELECTRICAL WORLD of March 19, 1892.

	March 13, High speed.	March 20, Low speed.
Av. electrical h. p. developed in 10 hours	601	630
Max. electrical h. p. developed in 10 hours	859	966
Min. electrical h. p. developed in 10 hours	345	363
Oil used in 10 hours	7 gal.	7 gal.
Water consumption for 10 hours	4,170 cu. ft.	3,660 cu ft.
" " per av. elec. h p. per hr.	10.2 lbs.	26.3 lbs.
" evaporated per lb. coal per hour	6.5 lbs.	7.0 lbs.
Bituminous slack coal used in 10 hours	38,600 lbs.	32,400 lbs.
Ashes made in 10 hours	4,444 lbs.	5,197 lbs.
Fuel used per av. elec. h. p. per hour	6.3 lbs.	5.1 lbs.
Combustible used per av. elec. h. per hr.	5.5 lbs.	4 3 lbs.
Coal per car mile	7.2 lbs.	6.4 lbs.
Average ampères per 10 hours	871	909
Maximum " " "	1,240	1,360
Minimum " " "	556	540
Average voltage " "	514	517
Maximum " " "	535	530
Minimum " " "	490	500
Number of readings of 15 second interval	2,400	2,400
Av. temperature of water from heaters	158°	195.5°
" " " " street main	39°	39°
" " outside atmosphere	32°	26°
Condition of weather	Light snow	Cloudy.
Height of barometer	Not taken	29.284
Av. steam pressure as per automatic steam registering diagram	88.8 lbs.	99.3 lbs.
Maximum steam pressure as per automatic steam registering diagram	102 lbs.	104 lbs.
Minimum steam pressure as per automatic steam registering diagram	85 lbs.	91 lbs.
Average chimney draught	¾ in.	¾ in.
Number of motor cars run on the line	62	62
" tow cars run on the line	10	10
" miles made by the motor cars	4,125.82	4,122.11
" " " " tow cars	821.30	679.66
" passengers carried on the cars	13,581	13,489
" miles made by Brooklyn motor cars	85.25	74.30
Number of miles made by Brooklyn tow cars	42.21	35.42
Number of miles made by Broadway motor cars	117.10	117.10
Number of miles made by Broadway tow cars	None.	None.
Number of Brooklyn motor cars	4	4
" " tow cars	2	2
" Broadway motor cars	5	5
" " tow cars	None.	None.
Total number of motor car miles	4,328.27	4,313.51
" " tow car miles	863.51	715.08
" " motor cars	71	71
" " tow cars	12	12
" " motor and tow cars	83	83
" " car miles made from power developed	5,191.15	5,028.59
Average horse power per car	7.24	7.59

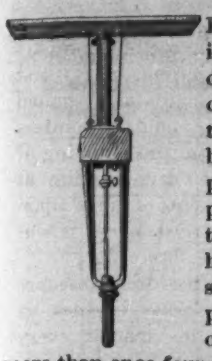
The average of the results given in the above table of the two tests of high and low speed plants may be summarized as follows:

Average of mean effective pressure engine No. 1	33.41
Average of mean effective pressure engine No. 2	39.73
Average of indicated mechanical h. p. engine No. 1	358.9
Average of indicated mechanical h. p. engine No. 2	417.75
Average indicated mechanical h. p. both engines	776.65
Average of electrical h. p.	647.33
Excess of mechanical h. p. over electrical	129.32
Gen. No. 14 as motor driving countershaft and other three generators light	47.653 e. h. p.
Gen. No. 13 as motor driving countershaft and other three generators light	52.375 e. h. p.
Gen. No. 15 as motor driving countershaft and other three generators light	53 e. h. p.
Gen. No. 16 as motor driving countershaft and other three generators light	47.32 e. h. p.
Average of the above	50.08 e. h. p.
Gens. No. 13 and No. 14 as motors driving shaft, two generators light and engine No. 2	138.06 e. h. p.
Gens. No. 13 and No. 14 as motors driving shaft, two generators light and engine No. 1	178.85 e. h. p.
Indicated mech. h. p. of engine No. 1 with jack shaft	46.98
Indicated mech. h. p. of engine No. 2 with jack shaft	35.06
Indicated mech. h. p. of engine No. 1 with countershaft and four No. 60 Edison generators light	76.57
Indicated mech. h. p. of engine No. 2 with countershaft and four No. 60 Edison generators	88.8
Indicated mech. h. p. of engine No. 1 with countershaft, four No. 60 Edison generators and engine No. 2	166.77
Indicated mech. h. p. of engine No. 2 with countershaft, four No. 60 Edison generators and engine No. 1	187.55

I intend to make one more test and then average the results of three, which surely should give a fair comparison of the high and low speed plants.

*A paper read before the Cleveland Electric Club.

The Manufacture of Arc Lamps for Low Tension Circuits.



THE history of the electrical industries is the history of a series of surprising developments. Even those who have carefully watched the growth of the telephone industry, the electric lighting business, or the electric railway enterprise, and who, it may be, have taken part in the development of these industrial improvements, can scarcely realize how these can possibly have attained to such enormous proportions in so brief a period. The inventor whose ideas were one day ridiculed as visionary has more than once found that a few weeks or months, or perhaps a year, have been more than sufficient to carry out his plans and build up a new and successful industry.

While this is true of the larger enterprises, it is no less true of their various branches. An admirable example of this phenomenal growth is found in the business of supplying arc lights for low tension circuits. Two and a half years ago electric lighting was almost universally done by the two familiar methods of high tension arc and low tension incandescent. With these two systems at his command the electrical engineer was able to supply the demands more or less completely of two very different varieties of patrons. With the series arc light run on high tension circuits he could furnish an illumination unsurpassed for general street lighting, the lighting of public squares and similar places of large area. With the incandescent lamp which came into service a little later he was able to supply a light suitable for private residences and for all places where beautiful and artistic lighting effects were desired. But between those who made use of the arc light for the illumination of large buildings, such as halls, factories, theatres, etc., and those who used the incandescent lamp for the lighting of smaller areas, there was a very large class who desired to use the electric light, but could not do so unless they were able to secure both arc and incandescent lights from the same circuit. To this class belong those, for instance, who wished to use the incandescent lights in their offices and arc lights in the factories adjoining such offices, as well as the very large class of merchants who desired to use arc lighting for the display of goods in store windows and incandescent lights for the general interior illumination of their stores.

FIG. 1.—AN ADJUSTER.

FIG. 2.—WINDING A MAGNET COIL.

FIG. 3.—JAPANNING THE PARTS.

FIG. 6.—ASSEMBLING THE LAMPS.

It was not surprising, then, that a number of inventors endeavored to solve the problem of burning arc lights off incandescent circuits. That there was a demand for an arc lamp of this kind there could be no doubt. There were many people who would not employ the high tension arc lamp in general use because of its alleged dangerous character, and these were constantly asking why it was not possible to obtain the same quality of light from the circuit which fed the incandescent lamp, of whose safety they were fully assured. Notwithstanding the great amount of ingenuity exercised by a number of inventors in endeavoring to perfect a lamp of this character it was not until about three years ago that a lamp was placed upon the market which proved thoroughly successful, and the business of supplying arc lights from incandescent circuits, which has assumed such enormous proportions, was inaugurated.

It may not prove unprofitable to those who are interested in this comparatively recent industry to briefly describe the manufacture of arc lamps for incandescent circuits. No better example of a well conducted factory of this kind can be found than that of the Electric Construction and Supply Company, of Peabody, Mass. Not only is the factory a busy one, but every part of it is of the most complete character, well equipped and admirably managed by men whose skill as machinists, or, more properly, mechanicians, is unsurpassed.

It would not be quite right for us to begin the study of the manufacture of the lamp in the workshop, for before it has reached this point a great deal of hard labor has been expended upon it in the experimental laboratory and designing room. With these, however, it is not our purpose to deal, except to say that Mr. Barton B. Ward, the inventor of arc lamps for incandescent circuits manufactured by this company, has had a wide experience in this class of work and has designed scores of modifications of these lamps which are now in successful use in hundreds of localities throughout the country.

At the factory of the company, as in all large industries of this kind, the work is done "by the piece," each employé having a certain part of the lamp to make. Each piece of the lamp is constructed in large quantities, and these are generally placed in the storeroom, so that the stock consists essentially of parts of lamps instead of completed ones. This method of manufacture is made possible because of the careful standardization of all the part before the working drawings are sent to the factory.

Our illustrations will give the reader an idea of the way some of the different parts are manufactured. For making the smaller parts girls are usually employed, as it has been found that they are much more rapid and accurate in their work, especially where the "faculty" of sensitive fingers is called for, as is the case in the winding of the magnet coils of the lamp. Here the wire is constantly passed through the fingers of the operator as it is wound on the spool, and the slightest defect in the insulation is detected and at once repaired. The resistance of each coil is carefully measured by a Wheatstone bridge as it is wound, and just enough wire is put on to give a certain specified resistance. These coils when finished are japanned and baked until the insulation is thoroughly dry.

An interesting process is that of cutting the gear teeth in the edge of the long rod which supports and feeds downward the upper carbon. The rod is square in cross-section, and the teeth occur on only one of the four edges. Thirty-six of these rods are fastened in a fixed position to the circumference of a cylinder, so that the edge upon which the gear is to be cut is at the outside. The drum is then revolved in a lathe, and the cutting tool cuts a tooth in each one of the 36 rods, its depth being accurately measured by a gauge. In this way each tooth is cut rapidly and accurately, and the brass rods are passed in to be polished and properly finished. The same care is taken in the construction of each part of the lamp, so that when the parts are all finished there remains only the putting of them together to make a satisfactory and successful lamp.

At the Peabody factory parts for the different style lamps sold by the company are made up in lots of two thousand each. The New York office designates the number of each style of lamp to be completed from these parts. If an order is received at the factory to ship to New York 300 of a certain style of lamp, the work of assembling these three hundred lamps begins immediately. Three hundred of each of the parts that make up the completed lamp of this particular style are taken from the storeroom, Fig. 5, to the assembling room, where the work of putting these parts together is carried forward with great rapidity. In our illustration, Fig. 6, a view of one side of this room, which is

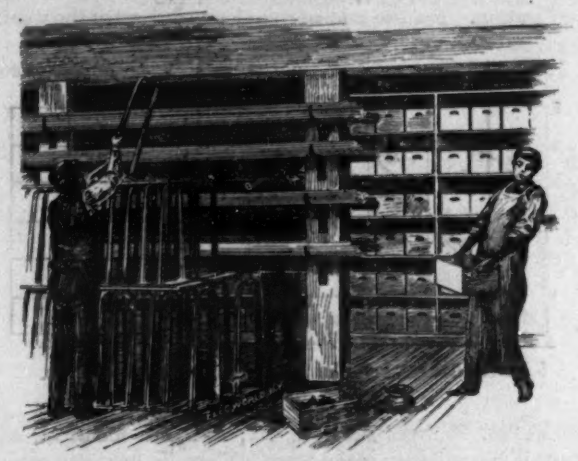


FIG. 5.—LAMP DEPARTMENT OF THE STOCK ROOM.

80 feet square, is shown, a number of employés being at work putting the lamps together.

When the workmen in the assembling room have completed the lamps by putting together the various rods, magnet coils and mechanism of the lamps, they are hung from the ceiling of the room on iron rods, some of which are shown in the illustration of the assembling room. Here they are thoroughly tested with the magneto, Fig. 4, to see if they are properly connected, and that the insulation is perfectly satisfactory. The lamps are then transferred to the testing room, where they are placed under conditions similar to those found upon the circuits for which they are constructed. Here the carbons are placed in the lamps preparatory to making the final test. These carbons, by the way, are manufactured especially for this work. The current is turned on, the testing circuit being fed by a 300-light Edison dynamo, which supplies current at a pressure of 110 volts, and the lamps are burned under these conditions long enough to be so carefully regulated that the arc is perfectly steady and quiet. After a satisfactory test has been made in this way the lamps are sent to the shipping department of the factory, where they are boxed for transportation, a complete stock of the different styles of lamps manufactured by the company being carried at its New York headquarters.

This process of manufacture is essentially the same for all varieties of the low tension arc lamp, although in this factory alone over 50 modifications of the lamp are made for

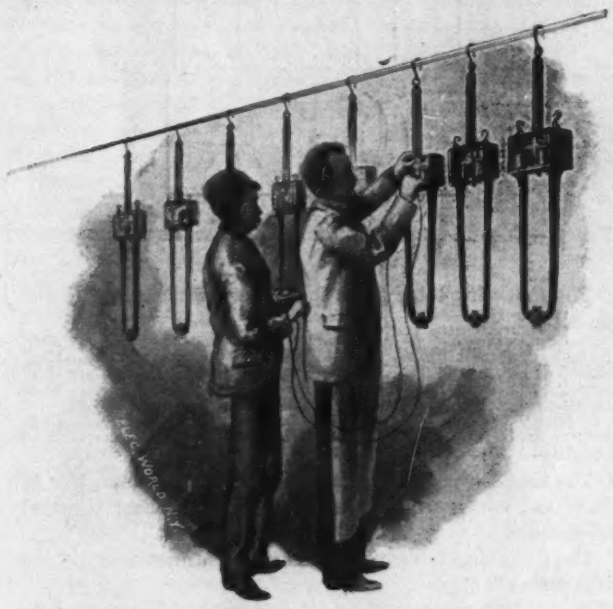
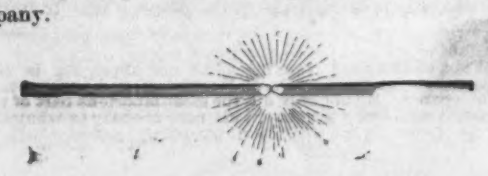


FIG. 4.—TESTING WITH THE MAGNETO.

various voltages, and for special uses, such as photo-engraving, marine and theatrical work, and the field of application for this class of lamps is constantly increasing. The latest production of this factory in the way of new lamps is along the line of ornamental and artistic designs for hotel corridors, dining rooms, stores, etc.

As illustrating the remark made at the outset that the growth of this enterprise has been phenomenal in its character, it may be mentioned that in the factory we have been describing the business has increased so rapidly that in the first quarter of 1892 it was 250 per cent. greater than for the corresponding quarter of 1890. The philosophical student who seeks the reasons for this healthy and successful growth of a new industry will find that it is due to three causes, viz., the great demand for the low tension arc lamp, the successful operation of this particular lamp, and to the excellent management of Messrs. Torrey and Corey, respectively the president and general manager of the company.



Dynamo-Electric Machinery.*

BY J. HOPKINSON,† F. R. S., AND E. WILSON.

The following is intended as completion of a paper by Drs. J. and E. Hopkinson (*Phil. Trans.*, 1886, p 331). The motive is to verify by experiment theoretical results concerning the effect of the currents in the armature of dynamo machines on the amount and distribution of the magnetic field which were given in that paper, but which were left without verification. For the sake of completeness, part of the work is given over again.

The two dynamos experimented upon were constructed

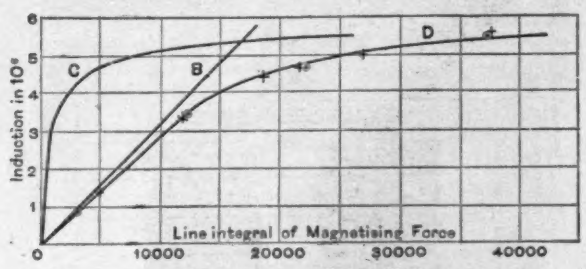


FIG. 1.—LINE INTEGRAL OF MAGNETIZING FORCE.

by Messrs. Siemens Bros. & Co., and are identical, as far as it is possible to make them. They are mounted upon a common base plate, their axles being coupled together, and are referred to in this paper respectively as No. 1 and No. 2.

Each dynamo has a single magnetic circuit consisting of two vertical limbs extended at their lower extremities to form the pole pieces, and having their upper extremities connected by a yoke of rectangular section. Each limb, together with its pole piece, is formed of a single forging of wrought iron. These forgings, as also that of the yoke, are built up of hammered scrap iron, and afterward carefully annealed. Gun-metal castings bolted to the base-plate of the machine support the magnets.

The magnetizing coils on each limb consist of 16 layers of copper wire two millimetres diameter, making a total of 3,968 convolutions for each machine. The pole pieces are bored out to receive the armature, leaving a gap above and below subtending an angle of 68 degrees at the centre of the shaft. The opposing surfaces of the gap are 1.4 centimetres deep.

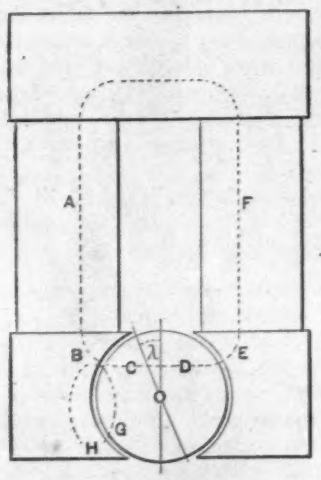


FIG. 2.—CLOSED LINE THROUGH MAGNETS AND ARMATURE.

The following table gives the leading dimensions of the machine:

	Cm.		Cm.
Length of magnet limb....	66.04	Width of yoke.....	12.06
Width of magnet limb	11.43	Depth of yoke.....	11.43
Breadth of magnet limb	38.10	De th of pole piece.....	20.32
Distance between centres of limbs	23.50	Thickness of gun metal base	19.80
Bore of fields	21.21	Width of gap.....	12.06
Length of yoke.....	38.10		

The armature core is built up of soft iron discs, No. 24 B. W. G., which are held between two end plates screwed on the shaft.

The following table gives the leading dimensions of the armature:

	Cm.
Diameter of core	18.41
Diameter of shaft.....	4.76
Length of core.....	38 10

The core is wound longitudinally according to the Hefner von Alteneck principle with 208 bars made of copper strip, each 9 millimetres deep by 1.8 millimetres thick. The commutator is formed of 52 hard drawn copper segments insulated with mica, and the connections to the armature so made that the plane of commutation in the commutator is vertical when no current is passing through the armature.

Each dynamo is intended for a normal output of 80 ampères 140 volts, at 880 revolutions per minute. The resistance of the armature measured between opposite bars of the commutator is 0.042 ohm, and of each magnet coil 12.3 ohms.

In the machine the armature core has a greater cross-section than the magnet cores, and consequently the magnetizing force used therein may be neglected. The yoke has the same section as the magnet cores, and is therefore included therein, as is also the pole piece. The formula

* Abstract of paper read before the Royal Society.

† It must not be supposed from his name not appearing in this short paper that my brother, Dr. E. Hopkinson, had a minor part in the earlier paper. He not only did the most laborious part of the experimental work, but contributed his proper share to whatever there may be of merit in the theoretical part of the paper.—J. H.

connecting the line integral of the magnetizing force and the induction takes the short form

$$4\pi n c = 2l_2 \frac{I}{A_2} + l_3 f\left(\frac{\nu I}{A_3}\right)^*$$

where

n is the number of turns round magnet.

c is the current round magnet in absolute measure.

l_2 the distance from iron of armature to rim of magnet.

A_2 the corrected area of field.

I the total induction through armature.

l_3 the mean length of lines of magnetic force in magnets.

A_3 the area of section of magnets.

ν the ratio of induction in magnets to induction in armature.

f the function which the magnetizing force is of the induction in the case of the machine actually taken from Dr. J. Hopkinson on the "Magnetization of Iron," *Phil. Trans.*, 1885, Figs. 4 and 5. plate 47.

In estimating A_2 we take the mean of the diameter of the core and of the bore of the magnets 19.8 centimetres, and the angle subtended by the pole face 112 degrees, and we add a fringe all round the area of the pole face equal in width to the distance of the core from the pole face. This is a wider fringe than was used in the earlier experiments (*Phil. Trans.*, p. 337), because the form of the magnets differs slightly. The area so estimated is 906 square centimetres.

l_2 is taken to be 108.8 centimetres.

A_2 is 435.5 square centimetres.

ν was determined by the ballistic galvanometer to be 1.47.

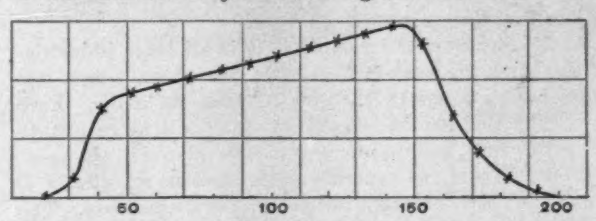


FIG. 3.—NO. 1 AS A DYNAMO.

It is to be expected that, as the core is actually greater in area than the magnets, ν will be more nearly constant than in the earlier experiments. It was found to be constant within the limits of errors of observation.

Referring to Fig. 1, the curve C is the curve $x = l_3 f\left(\frac{\nu y}{A_3}\right)$ and the straight line B is the curve $x = 2l_2 \frac{y}{A_2}$ while the line D is the characteristic curve of the machine $x = 2l_2 \frac{y}{A_2} + l_3 f\left(\frac{\nu y}{A_3}\right)$ as given by calculation.

The marks + indicate the results of actual observations on machine No. 1, and the marks o the results on machine No. 2, the total induction I being given by the equation:

$$I = \frac{\text{Potential difference in volts} \times 10^8}{208 \times \text{revolutions per second}}.$$

Experiments made upon the power taken to drive the machine under different conditions show that it takes about 250 watts more power to turn the armature at 660 revolutions when the magnets are normally excited than when they are not excited at all. The volume of the core is 9,465 cubic centimetres, or in each complete cycle the loss per cubic centimetre is

$$\frac{250 \times 10^7}{11 \times 9{,}465} = 24{,}000 \text{ ergs.}$$

The loss by hysteresis is about 13,000 (*Phil. Trans.*, 1885, p. 463) if the reversals are made by variation of intensity of the magnetizing force, and the iron is good wrought iron. This result is similar to that in the earlier paper (p. 352), where it is shown that actual loss in the core, when magnetized, is greater than can be accounted for by the known value of hysteresis.

Effects of the Current in the Armature.—Quoting from the Royal Society Paper, p. 342, "The currents in the fixed coils around the magnets are not the only magnetizing forces applied in a dynamo machine; the currents in the moving

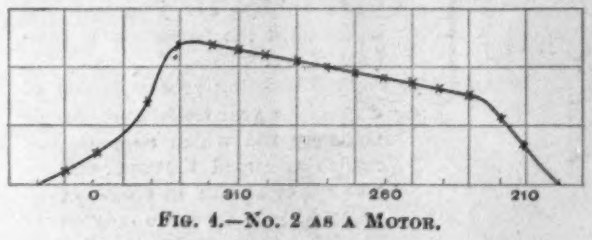


FIG. 4.—NO. 2 AS A MOTOR.

coils of the armature have also their effect on the resultant field. There are in general two independent variables in a dynamo machine—the current around the magnets and the current in the armature, and the relation of E. M. F. to currents is fully represented by a surface. In well constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. When a section of the armature coils is commutated it must inevitably be momentarily short-circuited, and, if at the time of commutation the field in which the section is moving is other than feeble, a considerable current will arise in that section, accompanied by waste of power and destructive sparking.

"Suppose the commutation occurs at an angle λ in advance of the symmetrical position between the fields, and that the total current through the armature be C, reckoned positive in the direction of the resultant E. M. F. of the

* *Phil. Trans.*, p. 335.

machine, *i. e.*, positive when the machine is used as a generator of electricity. Taking any closed line through magnets and armature, symmetrically drawn as $A\,B\,C\,D\,E\,F\,A$ (Fig. 2), it is obvious that the line integral magnetic force is diminished by the current in the armature included between angle λ in front and angle λ behind the plane of symmetry. If m be the number of convolutions of the

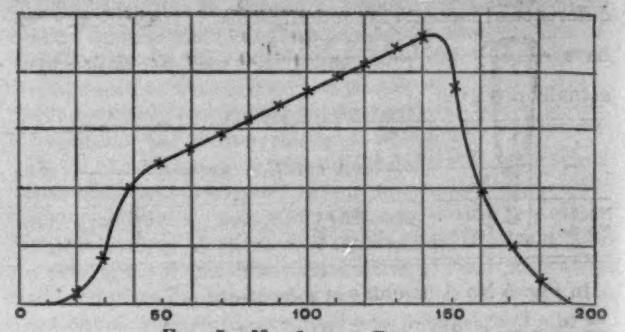


FIG. 5.—NO. 1 AS A DYNAMO.

armature, the value of this magnetizing force is $4\pi C \frac{m 2\lambda}{2\pi} = 4\lambda\, m\, C$ opposed to the magnetizing force of the fixed coils on the magnets. Thus, if we know the lead of the brushes and the current in the armature, we are at once in a position to calculate the effect on the E. M. F. of the machine. A further effect of the current in the armature is a material disturbance of the distribution of the induction over the bored face of the pole piece; the force along $B\,C$ is by no means equal to that along $D\,E$. Draw the closed curved $B\,C\,G\,H\,B$, the line integral along $C\,G$, and $H\,B$ is negligible. Hence the difference between force $H\,G$ and $B\,C$ is equal to $4\pi C \frac{m\kappa}{2\pi} = 2\kappa\, m\, C$, where κ is the angle $C\,O\,G$."

To verify this formula is one of the principal objects of this paper.

A pair of brushes having relatively fixed positions near together, and insulated from the frame and from one another, are carried upon a divided circle, and bear upon the commutator. The difference of potential between these brushes was measured in various positions round the commutator, the current in the armature, the potential difference of the main brushes, and the speed of the machine being also noted.

The results are given in Figs. 3, 4, 5, and 6, in which the

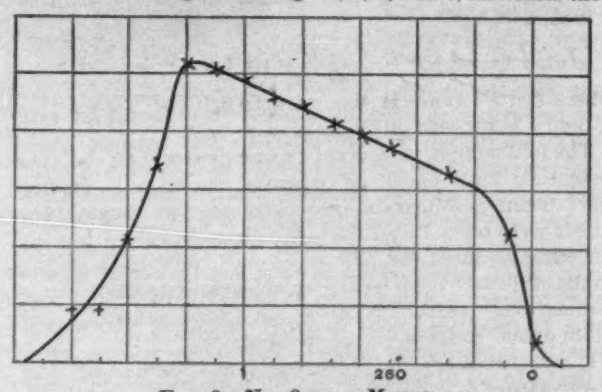


FIG. 6.—NO. 2 AS A MOTOR.

ordinates are measured potential differences, and the abscissæ are angles turned through by the exploring brushes.

The potential differences in Fig. 3 were measured by a Siemens voltmeter, and each ordinate is, therefore, somewhat smaller than the true value, owing to the time during which the exploring brushes were not actually in contact with the commutator segments. But this does not affect the results, because the area is reduced in the same proportion as the potential differences. In Figs. 4, 5 and 6 the potential differences were taken on one of Sir William Thomson's quadrant electrometers, and are correct.

Take Fig. 3, in which machine No. 1 is a generator. A centimetre horizontally represents 10 degrees of lead, and the ordinates represent differences of potential between the brushes. The area of the curve is 61.3 square centimetres, and represents 130 volts and a total field of $\frac{130}{104} \times \frac{1}{20} \times 10^8 = 4.31 \times 10^6$ lines of induction. This is, of course, not the actual field, which is three per cent. greater on account of the resistance of the armature, but is represented by an area three per cent. greater. An ordinate of one centimetre will represent an induction of $\frac{4.31}{61.3} \times 10^6 = 7.0 \times 10^4$ lines in 10 degrees. The area of 10 degrees is $39.5 \times 1.73 = 68.3$ square centimetres.* Hence, an ordinate of one centimetre represents an induction of 1,024 lines per square centimetre. The difference between ordinates at 50 degrees and 140 degrees is 2.5; hence the difference of induction is actually 2,560. Theoretically, we have $\kappa = \frac{1}{4}\pi\, m = 104\, C = 9.4$. Therefore, $2\kappa\, m\, C = 3{,}072$, and this is the line integral of magnetizing force round curve.

Let A be the induction at 50 degrees, and $A + \delta$ at 140 degrees; these also are the magnetizing forces. Hence $(A + \delta)\,1.4 - A\,1.4 = 2\kappa\, m\, C$; $\delta = 2{,}200$ as against 2,560 actually observed.

Take Fig. 4, in which No. 2 machine is a motor. The total field $= \frac{107}{104} \times \frac{1}{20} \times 10^8 = 5.15 \times 10^6$ lines of induction. Since the area of the diagram is 53.5 square centi-

*In calculating this area, the allowance for fringe at ends of armature is taken less than before, because the form of opposing faces differs.

metres, an ordinate of 1 centimetre = $\frac{5.15}{58.5} \times 10^6 = 96 \times 10^4$ lines of induction in 10 degrees. Hence an ordinate of 1 centimetre represents an induction of $\frac{9.6 \times 10^4}{68.8} = 1{,}400$ lines per square centimetre. The difference between ordinates at 320 degrees and at 230 degrees is 2.0; hence, the difference of induction is actually 2,800. Theoretically we have $\frac{2 \kappa m C}{l} = \frac{3\frac{1}{2} \times 104 \times 11.4}{1.4} = 2{,}666$, as against 2,800 actually observed.

—	Potential on magnets.	Potential on brushes.	Induction $I = F(4\pi nc)$
No. 1.....	24	86.4	2.82×10^6
No. 2.....	29	101.7	3.30×10^6

We have further:

$\gamma = 0.45$ for No. 1. $\lambda = 0.5$ for No. 2.

$\frac{4 m C}{\nu} = 2{,}920.$ $\frac{\nu - 1}{\nu} 4 m C \frac{A_2}{2 l_2} = 443{,}800.$

—	$\frac{4 \lambda m C}{\nu}$.	$\frac{\nu-1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2}$.	$4 \pi n c \frac{4 \lambda m C}{\nu}$.	$F\left(4 \pi n c \frac{4 \lambda m C}{\nu}\right)$.	$F\left(4 \pi n c - \frac{4 \lambda m C}{\nu}\right) - \frac{\nu-1}{\nu} 4 \lambda m C \frac{A_2}{2 l_2}$.
No. 1.....	1,314	199.700	7,588	2.41×10^6	2.21×10^6
No. 2.....	1,460	221,900	9,290	2.90×10^6	2.68×10^6

In Fig. 5 No. 1 machine is a generator. The total field = $\frac{52}{104} \times \frac{1}{12.6} \times 10^8 = 3.97 \times 10^6$ lines. The area of the diagram is 90.9 square centimetres, and therefore an ordinate of 1 centimetre = $\frac{3.97}{90.9} \times 10^6 = 4.37 \times 10^4$ lines in 10 degrees. Hence, an ordinate of 1 centimetre represents an induction of $\frac{4.37 \times 10^4}{68.3} = 639$ lines per square centimetre. The difference between ordinates at 50 degrees and at 140 degrees is 4.5; hence, the difference of induction is actually 2,877. Theoretically, we have $\frac{2 \kappa m C}{l} = \frac{3\frac{1}{2} \times 104 \times 12.9}{1.4} = 3{,}010$, as against 2,877.

In Fig. 6 No. 2 machine is a motor. The total field = $\frac{63.5}{104} \times \frac{1}{12.3} \times 10^8 = 4.96 \times 10^6$ lines, the area of the diagram 12.2 square centimetres, and therefore an ordinate of 1 centimetre = $\frac{4.96}{112.2} \times 10^6 = 4.42 \times 10^4$ lines in 10 degrees. Hence, an ordinate of 1 centimetre represents an induction of $\frac{4.42}{68.8} \times 10^4 = 647$ lines per square centimetre. The difference between ordinates at 323 degrees and 233 degrees is 4.2; hence, the difference of induction is actually 2,718. Theoretically, we have $\frac{2 \kappa m C}{l} = \frac{3\frac{1}{2} \times 104 \times 12.3}{1.4}$ = 2,870, as against 2,718 actually observed.

At page 345 of the paper on dynamo-electric machinery it is shown that

$$I + \frac{\nu - I}{\nu} 4 \lambda m C \frac{A}{2 l_2}^2 = F\left(4 \pi n e - \frac{4 \lambda m C}{\nu}\right),$$

where $I = F(4\pi nc)$ is the characteristic curve when $C = 0$, and λ is the lead of the brushes.

The following is an endeavor to verify this formula. The potentials both upon the magnets and upon the brushes were taken by a Siemens' voltmeter, and are rough. The speeds were taken by a Buss tachometer, and there is some uncertainty about the precise lead of the brushes, owing to the difficulty in determining the precise position of the symmetrical position between the fields, and also to the width of the contacts on the commutator.

It was necessary, in order to obtain a marked effect of the armature reaction, that the magnet field should be comparatively small, that the current in the armature should be large, and the leads of the brushes should be large.

The two machines had their axles coupled so that No. 1 could be run as a generator, and No. 2 as a motor. The magnets were in each case coupled parallel, and excited by a battery each through an adjustable resistance. The two armatures were coupled in the series with another battery, and the following observations were made:

—	Potential on magnets in volts	Potential on brushes.	Speed per minute.	Current in amperes	Lead of brushes.
No. 1..	24—24	63—67	880	101—103	25°
No. 2..	29—29	85—84	880	102—103	29°

From which we infer:

—	Current in magnet.	$4 \pi n c$.	Corrected potential for resistance of armature.	Total induction I.
No. 1.....	1.78	8,900	70.8	2.90×10^6
No. 2	2.15	10,750	80.7	2.65×10^6

As there was uncertainty as to the precise accuracy of the measurements of potential, it appeared best to remeasure the potentials with no current through the armature with the Siemens voltmeter placed as in the last experiment. Each machine was, therefore, run on open circuit with its magnets excited, and its potential was measured.

—	Potential on magnets in volts.	Potential on brushes.	Speed per minute.	Potential at 880 revs.
No. 1.....	25—25	90—90	880	90.0
No. 2.....	28 28	79—80	715—710	98.2

From which we infer, since we are upon a part of the characteristic which is practically straight, in which case, of course, the formula is reproduced very nearly to

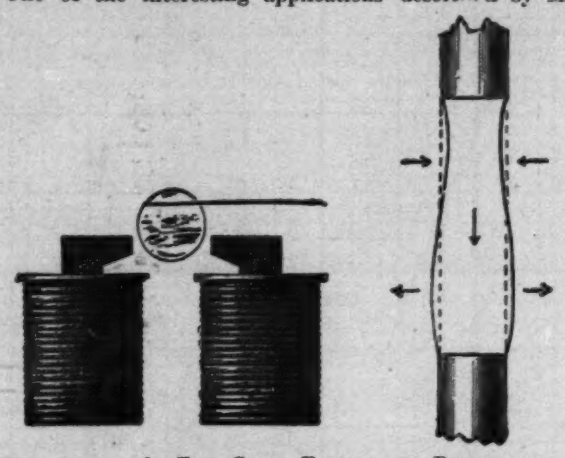
$$I = \frac{A_2}{2 l_2} (4 \pi n c - 4 m \lambda C).$$

It has already appeared that experiment gives for I in No. 1, 2.3×10^6, and in No. 2, 2.65×10^6. The difference is probably due to error in estimating the lead of the brushes, which is difficult, owing to uncertainty in the position of the neutral line on open circuit.

The Use of the Soap Bubble in Electric and Magnetic Researches.

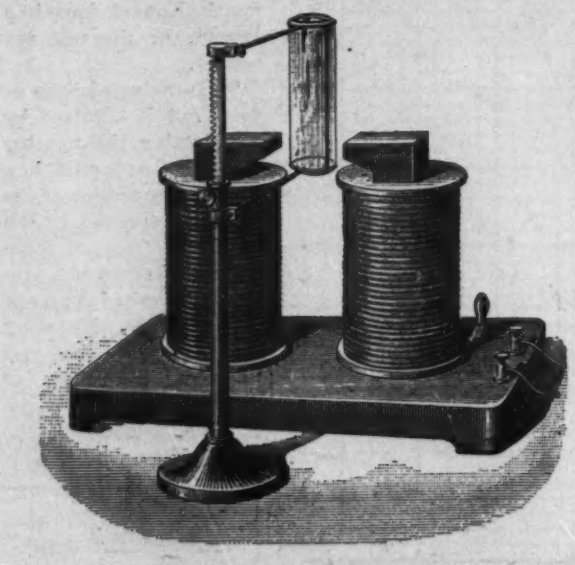
Mr. C. V. Boys recently described some interesting experiments showing how the ordinary soap bubble film may be used in illustrating and investigating electric and magnetic phenomena. As an exceedingly sensitive membrane which will respond to very minute forces the soap bubble film has probably no equal.

One of the interesting applications described by Mr.



FIGS. 1 AND 2.—THE SOAP BUBBLE IN ELECTRICAL EXPERIMENTS.

Boys is an illustration of the fact brought out by Dewar, that oxygen is magnetic. Owing to the difficulties experienced in examining the magnetic properties of oxygen few physicists have as yet been able to study it, but the use of the soap bubble film suggested by this investigator makes it an exceedingly simple matter. Referring to Fig. 1, a soap bubble filled with oxygen is suspended by means of a wire ring between the poles of a powerful electromagnet. As soon as the magnet is energized a slight movement of the bubble will take place, but as it is exceedingly small it is necessary to be quite close to the bubble in order to notice it. In order to render this movement more apparent, a cylindrical bubble may be used as shown in Fig. 2. The bubble in this case is blown between two rings or between the ends of two tubes. Such a bubble is said to be stable when its length is smaller than its circumference, but the nearer its length approaches the periphery



FIGS. 3, 5, 6 AND 7.—THE SOAP BUBBLE IN ELECTRICAL EXPERIMENTS.

the more it will become unstable. When it reaches this critical value the slightest change will cause a rupture followed by a separation into two bubbles, one on each ring. In this unstable state it is therefore very sensitive to changes. Let such a cylindrical bubble blown with oxygen be placed between the poles of a powerful magnet as shown in Fig. 3 and let its length be adjusted relatively to its periphery so as to make it as unstable as possible. On exciting the magnet, the oxygen will be attracted and the bubble will tend to spread out at the lower part of the cylindrical bubble as shown in Fig. 2, and as the bubble is in an unstable state it will then immediately break up into two as shown in Fig. 4, in which the lower one is, of course, the larger.

Soap bubbles may also be used as an electroscope, and will then be found to make an instrument of most extraordinary sensitiveness. Let two bubbles be suspended, as shown in Fig. 5, from a support of hard rubber which insulates them. They are placed so as to be in contact with each other, and it will be found that they will remain so

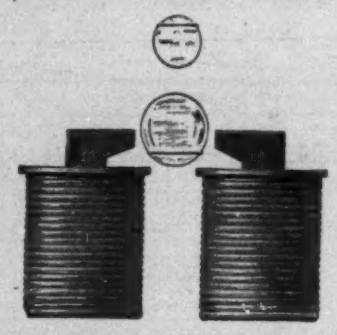


FIG. 4.—THE SOAP BUBBLE IN ELECTRICAL EXPERIMENTS.

without uniting. If a piece of sealing wax or like substance be electrified by rubbing, and be held at a distance of several metres from the bubbles, they will at once unite, forming one bubble, as shown in Fig. 7.

Instead of placing the two bubbles next to each other they may be blown one inside of the other, as shown in Fig. 6; in doing this the outside bubble must be weighted with some drops of the solution in order to elongate it, and the inside bubble must be quite free from the drop which usually forms at the bottom. If now an electrified body be brought even quite close to these they will be found to remain separated instead of uniting into one bubble as in the other case. This experiment shows in a very simple way the well known properties of an electric screen to protect from electrification bodies contained within such a screen.

The illustrations are taken from a recent number of *L'Industrie Electrique*.

Plans of the Royal Electric Company of Montreal.

The Royal Electric Company of Montreal, Canada, has in contemplation some very important plans for increasing its business interests as well as the capacity of its plant. At a recent meeting of the company a change was made in the board of directors, there being three new members appointed to the board, a furtherance of the desire of those interested in the company to strengthen it financially and infuse new blood and energy into it. The change, it is stated, has been brought about by the company's decision to carry out a most extensive and important undertaking, which contemplates the utilization of the Chambly Rapids for the purpose of supplying lighting and power. The company has obtained a charter for utilizing the Chambly Rapids, and just as soon as the water is low enough operations are to be commenced. The rapids are susceptible of developing, it is estimated, at lowest water, over 20,000 h. p. The company will thus be enabled to distribute current in Montreal, not only the arc and incandescent lights, but also to supply power for manufacturing purposes, running elevators, mills, etc. Once the work is commenced it is to be carried on vigorously and by the end of the present summer one-third of the power, it is expected, will be developed. It will probably be two years before the full power has been developed. This is only a part of the future policy of the company, which it would seem has entered upon an entirely new era. In a few weeks part of the company's works will be transferred into a new four story building on Queen street, in Montreal. Besides supplying the city with light, the company will devote part of its attention to the manufacture of railway motors and all other electric appliances, and will have the equipping of the new electric street railway service and supplying it with power.

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Dynamo and Motor Calculation.

BY C. H. BEDELL.

In the calculation of the different parts of a dynamo or motor the work is, of course, divided into the calculation of the armature and that of the field; but as the capacity and smooth operation depend principally upon the construction of the armature, it should be worked out first. This work is best divided into two parts, and since the dynamo is primarily a generator of E. M. F., the first consists of the calculation of those parts which effect the generation of the E. M. F., and the second consists of so proportioning the parts that they will stand the currents which may be allowed to flow.

The part of the work which I wish now to consider is that of the generation of the E. M. F. In order to calculate with certainty, one must know to what extent the proposed field will saturate the core of the armature, since the E. M. F. is generated by the wires of the armature cutting the lines of force which the field causes to pass through the armature core.

One definition of an absolute unit of E. M. F. is that E. M. F. which is generated by a conductor cutting one line of force once a second.

Broadly, the E. M. F. generated equal lines of force cut by the number of times they are cut per second. The E. M. F. is consequently proportional to the number of lines of force cut, and also to the rate at which they are cut.

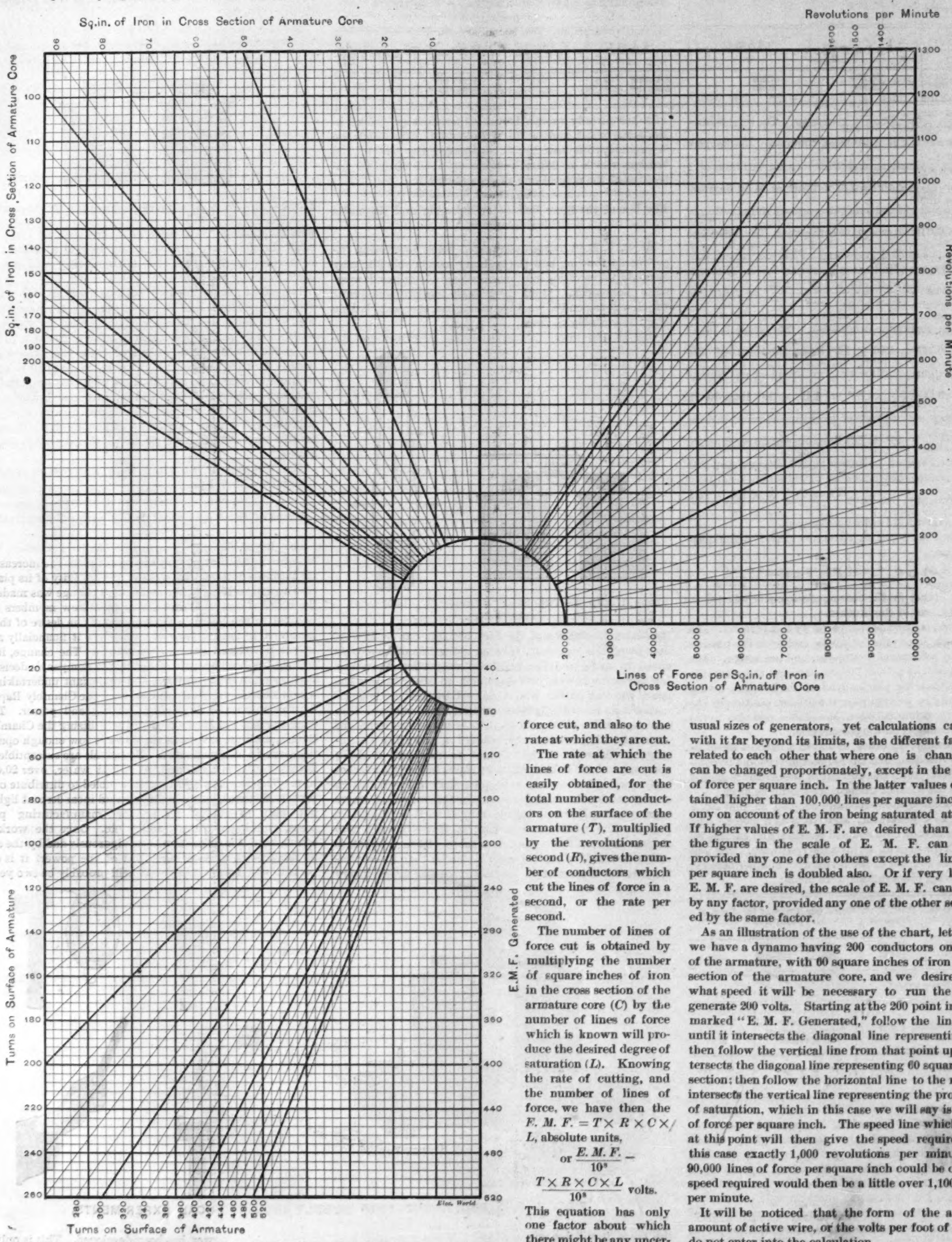

Sq.in. of Iron in Cross Section of Armature Core
Revolutions per Minute
Lines of Force per Sq.in. of Iron in Cross Section of Armature Core
Turns on Surface of Armature
E.M.F. Generated
Elec. World

CHART FOR USE IN DYNAMO DESIGNING.

The rate at which the lines of force are cut is easily obtained, for the total number of conductors on the surface of the armature (T), multiplied by the revolutions per second (R), gives the number of conductors which cut the lines of force in a second, or the rate per second.

The number of lines of force cut is obtained by multiplying the number of square inches of iron in the cross section of the armature core (C) by the number of lines of force which is known will produce the desired degree of saturation (L). Knowing the rate of cutting, and the number of lines of force, we have then the $E.\ M.\ F. = T \times R \times C \times L$, absolute units,

$$\text{or } \frac{E.\ M.\ F.}{10^8} = \frac{T \times R \times C \times L}{10^8} \text{ volts.}$$

This equation has only one factor about which there might be any uncertainty, which is the factor L, but as a very slight acquaintance with the form of dynamo to be constructed, or a careful calculation of the magnetic circuit, will give the possible degree of saturation, there can be said to be very little uncertainty even in this factor. The most satisfactory degree of saturation of the armature core is with 90,000 to 100,000 lines of force per square inch of iron in the cross-section of the armature core, which can be obtained with the usual percentage of watts used in the field. The annexed chart will greatly facilitate this calculation. It is of the same general plan as Mr. Carl Hering's wiring charts* published in his Wiring Computer, and is used in the same manner. The interpolations for values between the diagonal lines are different in this chart, as the readings in the upper left hand field should be along a horizontal line, and those in the upper right hand and in the lower left hand field should be along vertical lines.

It will be noticed that although the chart covers all the usual sizes of generators, yet calculations can be made with it far beyond its limits, as the different factors are so related to each other that where one is changed another can be changed proportionately, except in the case of lines of force per square inch. In the latter values cannot be obtained higher than 100,000 lines per square inch with economy on account of the iron being saturated at that point. If higher values of E. M. F. are desired than those given, the figures in the scale of E. M. F. can be doubled, provided any one of the others except the lines of force per square inch is doubled also. Or if very low values of E. M. F. are desired, the scale of E. M. F. can be divided by any factor, provided any one of the other scales is divided by the same factor.

As an illustration of the use of the chart, let us suppose we have a dynamo having 200 conductors on the surface of the armature, with 60 square inches of iron in the cross section of the armature core, and we desire to know at what speed it will be necessary to run the armature to generate 200 volts. Starting at the 200 point in the column marked "E. M. F. Generated," follow the line to the left until it intersects the diagonal line representing 200 turns; then follow the vertical line from that point up until it intersects the diagonal line representing 60 square inch cross section; then follow the horizontal line to the right until it intersects the vertical line representing the probable degree of saturation, which in this case we will say is 100,000 lines of force per square inch. The speed line which also crosses at this point will then give the speed required, and is in this case exactly 1,000 revolutions per minute. If only 90,000 lines of force per square inch could be obtained, the speed required would then be a little over 1,100 revolutions per minute.

It will be noticed that the form of the armature, the amount of active wire, or the volts per foot of active wire, do not enter into the calculation.

In this method the number of lines of force which pass from any one pole into the armature core and the rate which the wires cut these lines of force form the basis of the calculation.

The maximum P. D. is between two points on the armature wire which just include all the lines of force which pass through the armature, to or from any one pole, as at

* See Electrical World, May 30, 1891, p. 395.

a and *b* in Fig. 2, if we are working with the lines that pass from the N. pole.

As far as the E. M. F. generated between *a* and *b* is concerned, it makes no difference in a ring armature what becomes of the lines of force after they pass those points, or what the other wires on the surface of the armature are doing. In a two-pole field the other portion of the armature wire passing under the S. pole cuts the same lines of force, and consequently the same number, and since the rate of cutting them is the same the E. M. F. generated is exactly the same as that generated under the N. pole. But as these two E. M. Fs. are in opposite directions no current flows around the armature, although the points of greatest P. D. are joined together by the parts of the armature wire not under the poles.

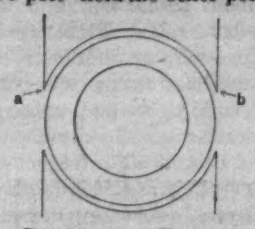


FIG. 2.—DIAGRAM OF DYNAMO POLES.

Since what becomes of the lines of force after passing the points *a* and *b* of a ring armature, or what the armature wires not between *a* and *b* are doing, makes no difference to the E. M. F. generated between *a* and *b*, the lines of force may be divided so as to pass from the armature into different poles, and the armature wires not between *a* and *b* may pass under any odd number of poles, and may generate under those poles different E. M. Fs. from those under the pole first considered. It is usual, however, to so build the different portions of a multipolar field that the E. M. F. generated under the poles is the same in amount, in order that all the terminals of the same potential may be joined together, thus connecting the different portions of the armature in parallel.

The methods of calculation given above, either by formula or chart, deal with the generation of the E. M. F. under one pole only, and consequently can be used for any direct current dynamo having a ring armature, whether for bipolar or multipolar fields.

In the case of drum armatures the conditions are a little different, as the return portion of a wire under the N. pole passes under the S. pole, and generates an E. M. F. which is added to that generated under the N. pole, increasing the E. M. F. between *a* and *b*. But the adjoining wire does not give its E. M. F. to *a* and *b*, but to corresponding points adjacent to the S. pole. Consequently it may be considered that one wire offsets the other, and the same formula and the charts therefore hold good for drum armatures also.

In cases of multipolar machines having the E. M. Fs. generated under like poles in series, the E. M. F. either of formula or chart should be increased in proportion to the number of such poles.

The square inch of iron in the cross section mentioned above has reference to the iron in the cross section through which the lines of force pass from any one pole.

The E. M. F. generated may be that of a dynamo, or that of a motor in the form of counter E. M. F. In each case allowance should be made for the loss in voltage due to the resistance of the armature, and also to whatever loss of E. M. F. there may be, due to the lead of the brushes. It is interesting to note that in armatures having the same cross section of core, the same degree of saturation, and rotating so that the lines of force are cut at the same rate, the capacities in watts are proportional to the number of poles used.

Experiments with Alternating Currents of High Potential and Low Frequency, and Opinions of Prominent Electricians on this Subject.

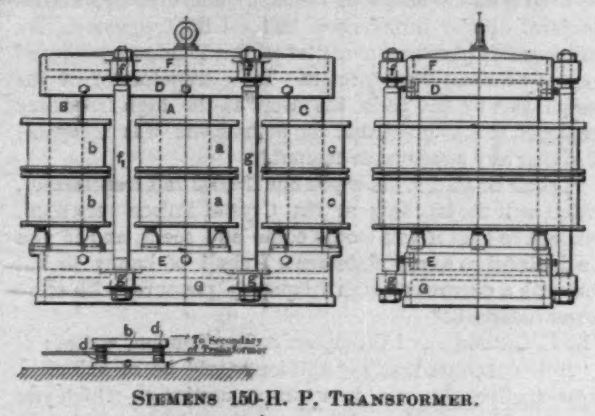
BY FRANK C. PERKINS.

The exhibit of Messrs. Siemens Bros. & Co. is among the most interesting at the Crystal Palace, London, and is made so from the very instructive experiments shown by Mr. Simpson, who has charge of the alternating high potential apparatus. The alternating current generator in the Siemens exhibit, to be seen in the machine room, is directly coupled to a vertical engine, and has a capacity of 40,000 watts (80 volts and 500 ampères) at a speed of 400 revolutions per minute. This current at 50 volts pressure is transformed to 2,500 volts by means of the Siemens cable transformer. At the above pressure it is conducted to the lecture room, where it is again transformed from 2,500 volts to 52,000 volts by a transformer with a capacity of 60,000 volts. This 130-h. p. transformer is not insulated by means of oil, as will be seen by the cuts shown, for which we are indebted to *Engineering*.

The respective windings are arranged as follows: Primary, 50 ampères, 2,500 volts; secondary, 2 ampères, 52,000 volts. It was designed by Messrs. Siemens Brothers & Co. for their experimental work in connection with alternating currents, and with it many very striking experiments have been carried out, which, up to the present, it is claimed, were only attainable by the use of high frequency currents. The frequency in these experiments was 66 per second. The magnetic part of this transformer is made throughout of soft laminated iron, and comprises three vertical limbs, *A*, *B*, *C*, united at the top and bottom by horizontal slabs *D* and *E* let into the castings *F* and *G*, which respectively form the base and cap of the transformer. Each of the castings *F* and *G* is provided with lugs *ff*, *gg*, and the whole is firmly held together by means of bolts *f*, *g*, passing through them. Almost the entire length of each bolt is covered with ebonite, so that the tendency for the electricity to arc across from the secondary to earth is reduced to a minimum. In this manner two complete paths for the induction are provided, and consequently the limb *A* has twice the sectional area of either *B* or *C*. Each of the limbs, *A*, *B*, *C*, is provided with a primary coil which is wound directly on to it with a conductor capable of carrying 50 ampères, special precaution being taken with respect to insulation. The secondary winding is wound on frames *aa*, *bb*, *cc*, two of which are carried upon each limb and are supported by porcelain insulators, as shown. An air space is left between each primary and the inside of the corresponding secondary, so that the latter is practically surrounded by an air insulation. Each frame is supplied with terminals and fuses, so that various combinations can be made with the separate windings at disposal. It need hardly be mentioned that the greatest care was taken with the secondary insulation.

The following are some of the interesting experiments performed with this transformer: A plate of glass about 2 feet square and 2½ millimetres thick was separated from two metals discs by means of ebonite distance pieces, each 2 millimetres thick, the whole being mounted on an ebonite stool. The terminals of the secondary winding were connected respectively with the discs. With a difference of potential of from 40,000 to 50,000 volts the glass would be pierced in less than one minute. In all of the experiments the voltage in the secondary of the high tension transformer is varied by varying the current in the field of the alternator.

An enormous arc varying from 1 foot to 2 feet in length was produced with the high voltage current by means of two carbons mounted on the ebonite rods. When the arc



SIEMENS 150-H. P. TRANSFORMER.

was produced the voltage at once fell to 20,000 volts, while before the arc was produced it was 50,000 volts.

A large tank was connected to one terminal of the transformer and the other terminal to a large metal tray below the tank. When the current was turned on and drops of water allowed to pass from the tank above to the tray, the current would pass around the drop, illuminating it as it fell and heating it to such a temperature that it would become steam before reaching the tray below.

A bank of 500 incandescent lamps were lighted to full candle power; they were connected in series, each requiring 100 volts, and hence requiring 50,000 volts to light to full candle power. When one of the lamps was broken the others did not go out as usual with lamps working in series, but the other lamps continued to burn, the current sparking across the terminals of the broken lamp. Among some of the experiments performed by Mr. Simpson with this current, whose frequency was 66 complete periods per second, were several of Mr. Tesla's experiments in which very much higher frequency was used.

The experiment with the two circular wires, one within the other, and connected with the terminals of the machine, showed the nodes as bright spots on the wires with great distinctness and regularity, these bright spots just appearing at 20,000 volts and increasing in brightness as the potential was increased to 50,000 volts. When the condenser was used the brilliant effect of lighting the space between the two rings showed up much better. The experiment of Mr. Tesla with an exhausted glass tube in an electric field between two metallic plates was also shown with this current, which was of low frequency. Many other interesting experiments were made which Mr. Tesla had previously made with currents of high frequency.

Among those who witnessed these experiments were Lord Kelvin (Sir Wm. Thomson), Prof. Crookes, Mr. W. H. Preece, Prof. Silvanus P. Thompson, William J. Hammer and others, well known in electrical circles. At the close of the lecture it was noticeable that many of those present expressed the opinion that the experiments just performed with alternating currents of 50,000 volts and frequencies as low as 66 alternations per second were in many respects the same as those shown by Mr. Tesla before the members of the American Institute of Electrical Engineers at Columbia College, at the Royal Institution in London, and recently in Paris.

It has many times been asked whether with these currents of high frequency, or in fact with alternating currents in general, Ohm's law holds perfectly true. In trying to get an expression of opinion from several parties on this subject, various answers were given and several wished to have some time to think over the matter and would make a statement in writing; accordingly the following questions were sent to a number of prominent electricians, from which various answers were received. Although at first sight it might appear that many did not believe that Ohm's law holds good, I think from the statements made below the majority think it does hold true when all resistances, and all E. M. Fs., are taken into consideration. The questions asked were as follows:

1. "Do you consider that the phenomena of Mr. Tesla's experiments are due to high frequency and high frequency currents alone?"

2. "Do you consider that Ohm's law holds perfectly true for alternating currents as well as for continuous currents?" and "for currents of high frequency as well as low frequency?"

3. For instance: "Taking the terminals of Mr. Tesla's apparatus, with a difference of potential of thousands of volts, and connecting the same with a copper wire of low resistance, or by Mr. Tesla's body, why should not enormous currents flow if $C = E \div R$? Do you consider it due to the high frequency of the current?"

4. "Again, if 2,000 volts is all that is necessary to kill a man, and if the resistance remains constant, and the E. M. F. rises to enormous values, why should not the current also rise to a very high value and produce the same result with a person in circuit?"

In answer to the above questions Mr. W. H. Preece, of the Post Office Department, London, makes the following reply:

"There can be no doubt that the success of Tesla's phenomena is due to the combination of high frequencies with high potentials. I do not think that either alone would produce such brilliant effects.

"There is no doubt that Ohm's law holds perfectly true under all circumstances whatever, but there are variations in dealing with alternating currents due to counter electromotive forces arising sometimes from electromagnetic, and sometimes from electrolytic effects, that cause departure easily calculable. The effect on the human frame is probably due to the counter E. M. F. set up by the decomposition of the liquids of the body.

"These counter effects are developing themselves in directions we least anticipated. There is no doubt that an arc behaves itself as though it had self-induction, and self-induction is a phenomenon that is very little understood and often misapplied. It is a term frequently used to hide our ignorance."

Prof. D. E. Hughes makes the following statements regarding the above questions:

"Regarding alternating currents of high frequency, I can only say that I have not much experience with such currents, but from my own experiments on self-induction I think I can fairly answer most of your questions.

"1. Mr. Tesla has not yet published his paper on the subject, but I believe he thought they were due to high voltage combined with high frequency, and in this, I believe, he is perfectly right.

"2. No. My own experiments and, I believe, all made by other experimenters show that, with alternating currents, we have to contend with self-induction, which interferes greatly with any rapid transmission of alternating currents. In fact I can image a voltage and high frequency so great that the best conductor would be almost opaque to electrical currents, and often air and other insulators will offer less resistance than a so-called good conductor."

Prof. William Crookes says: "I certainly consider that the striking phenomena of Mr. Tesla's experiments are due to the very rapid alternations he works with. I have not experimented sufficiently with Tesla's apparatus to enable me to say how Ohm's law applies to his currents. Rubbing a cat's back or a stick of sealing wax will give a half inch spark. This is equivalent to an E. M. F. of about 10,000 volts. But you cannot manufacture current by passing the spark through a wire of, say, one ohm resistance."

Prof. W. E. Ayrton, of the City and Guilds of London Institute, states that: "To answer these questions would require one to write a paper on the theory of rapidly alternating and intermittent currents. This I cannot do at the moment, I am sorry to say, but I may shortly add, however, that the equation $C = E \div R$ certainly does not hold in such cases if by R you mean the resistance as measured with a steady current."

Mr. Gisbert Kapp, electrician for the firm Johnson & Phillips, makes the following interesting replies:

"I do not feel competent to give an opinion on Mr. Tesla's experiments, as I have not made such experiments myself, but wishing to comply with your request, I give the following conjectures, which might, perhaps, help in explaining the matter:

"1. As to the physiological effects: We know that strong sound waves of sufficiently low periodicity may injure the drum of the ear, yet if we increase the frequency we get at last a note of so high a pitch that it does not affect the human ear at all. Also with light: The white rays of an arc light can injure the retina; but if you only get the ultra violet rays there is no effect. I quite admit that these analogies are not very scientific, but, perhaps, there is something in them.

"2. Self-induction effects: It is not the voltage which kills, but the current. Now, if owing to the high frequency the back E. M. F. of self-induction becomes very high, it is quite conceivable that the choking effect of the

body is sufficient to prevent the passage of more than a very few milliampères, which current can be taken without harm.

"3. Skin effect: Lord Kelvin (Sir William Thomson) showed that a conductor carries alternating currents more on the skin than the interior, the effect being the more marked the larger the conductor and the higher the frequency. It is at least conceivable that the Tesla current passes principally along the very outermost layer of the skin, and thus does not affect the vital parts of the body."

Mr. James Wimshurst, inventor of the Wimshurst machine, says:

"1. I was one of the many who had the pleasure of witnessing Mr. Tesla's interesting experiments, but I fail to see in them much if any more than a great expenditure of money and energy. A large part of the phenomenon may be due to statical charges having fairly high frequencies.

"2. I consider Ohm's law holds true for continuous currents, but that additional influences are imparted when alternating currents are used.

"3. 'Enormous currents' are produced only by enormous energy. $C = E \div R$ for direct flow, but in Mr. Tesla's experiments either the R was unknown or the necessary E was wanting. I think he would not venture to complete the circuit, his body only being the R. High frequencies add to the R, but the frequency he used did not, I think, so materially reduce the current as to make its quantity become less.

"4. In your last question you seem to omit the influence of chemical action producing resistance, or back E. M. F."

Dr. John Hopkinson replied as follows:

"I do not give expression to hastily formed opinions, and your questions would require considerable time to frame thoroughly satisfactory answers."

Dr. J. A. Fleming makes the following statements:

"You ask if Ohm's law is true for alternating currents of high frequency? What is commonly called Ohm's law is true as far as it goes, but it is not the whole of the story. When you are dealing with continuous or unvarying currents, the current strength is related to the impressed electromotive force in a very simple manner as expressed by the numerical law $R = E \div C$. The moment you have to deal with alternating or varying currents we have to take into account, in addition to the mere ohmic or true resistance of the circuit, the induction or self-induction of the circuit. If the frequency becomes very considerable, the capacity of the circuit has to be considered as well; and the current strength is then related to the impressed E. M. F. by a very complicated law which involves the resistance, inductance and capacity. Moreover, when the high frequency is employed the current in a copper wire is practically confined to the mere skin or surface of the wire. As regards the physiological effect of alternating currents of high frequency, it seems to be undoubtedly the fact that they are less injurious than currents of low frequency. The reason for this is partly physiological as well as physical. As a matter of fact, however, it is very interesting. When Mr. Tesla had his apparatus at the Royal Institution, following his example, I tried the shock from his high frequency coil and was surprised to find how slight it was. It will need much more research before your questions can be properly answered. As regards the flow of current in conductors under alternating E. M. F., you will find that explained in my treatise on 'The Alternating Current Transformer,' and the matter comes briefly to this: 'Ohm's law as an expression of a fact in continuous current flow is no use whatever as a rule for interpreting the greatly more complicated phenomena of alternating currents of high frequency.'"

Mr. Alexander Siemens, of the firm of Siemens Bros. & Co., says:

"The questions on these matters are not very easy to answer and this must be my excuse for not doing so sooner. The experiments which we are now making appear to indicate that some of the Tesla experiments can be repeated with alternating currents of low frequency. A full answer to your first two questions can, however, only be given after a long series of careful experiments.

"Ohm's law is certainly true for alternating currents as well as for continuous currents, also for high and low frequency. In your first example you overlook that it has not been proved that those enormous differences of potential really exist, and, further, that the source of electricity utilized in Mr. Tesla's experiments is not capable of producing such large currents, if these differences of potential are produced.

"I would compare this case (of Ohm's law being true under all circumstances) with that of the law of gravity. In a very complicated machine the latter law holds good, although the machine may be able to produce appearances which at first sight seem to contradict the law of gravity. In a similar manner the action of the potential difference may be considerably modified by the frequency, or by other causes, such as capacity, etc., and you cannot neglect the surrounding circumstances which may prevent the current rising in direct proportion to the increase in the difference of potential although the resistance remains the same (at least apparently). It is for instance pure conjecture that the resistance remains constant under the circumstances which are mentioned in the second example."

Mr. James Swinburne, electrician of the firm of Swinburne & Co., is making some interesting experiments with alternating currents of high potential, using about 100,000 to 130,000 volts, which will be described in a later article. The following statements were made by Mr. Swinburne in references to the above questions:

"1. I do not think Mr. Tesla has discovered, or claims to have discovered, any new phenomena. His experiments are more brilliant than those performed with Ruhmkorff coils or Wimshurst machines, because he has brought more modern knowledge to bear on the construction of his apparatus. The high frequency also enables him to get more brilliant effects where capacities are concerned, as, with a given E. M. F., the current into a condenser varies as the frequency."

"2. I consider Ohm's law holds good at all frequencies. Of course, self-induction and capacity become more important in determining the flow in any circuit the higher the frequency; but Ohm's law holds all the same.

"3. If Mr. Tesla touched two poles whose potential continued to differ by 2,000 volts he would be killed. If the frequency were very high a copper conductor of low resistance, say one ohm, would not take 2,000 ampères for two reasons. In the first place the conductor has some self-induction, and this would cause a back E. M. F., which at a very high frequency would reduce the current considerably. In the second place the initial induction of the different parts of the current stream would produce the 'skin effect,' so that with a very high frequency the apparent resistance of the copper would go up enormously. This 'skin effect' has been studied by Lord Kelvin (Sir William Thomson) and others, and can be calculated for any size of wire conductor if the frequency is stated.

"4. The reason why Mr. Tesla was not killed is that as soon as he touched his transformer the pressure ceased. It is the same as touching a small Wimshurst machine. It can give many thousands of volts, but only on open circuit.

"If an ordinary transformer is tested carefully it will be found that at full load the fall of pressure is too great to be accounted for by the resistance of the windings. The extra drop is due to magnetic leakage. This drop depends on the form of the transformer and on the frequency. By utilizing this phenomenon, Prof. Elihu Thomson produced constant current transformers. In a transformer of the design used by Mr. Tesla the drop at the high frequency employed was so great that the instrument was incapable of giving any appreciable current.

"I shall be glad to show you our 120,000 volt transformer, which will be on show at the Crystal Palace very soon. I should be glad if you would come and see it, and if you are doubtful as to my statements I shall be happy to kill you with a current of high frequency pressure, with some power behind it."

R. E. Crompton, of Crompton & Co., London, writes:

"I do not think that my opinion would be of sufficient value to affect the very interesting question on which you are now obtaining the opinions of English electrical engineers. Although I have considered the questions and talked them over with Mr. Tesla himself, I cannot give you answers which are satisfactory to myself and which I should care to put forward as an opinion deliberately expressed by me. On the whole, however, I think the balance of evidence is in favor of the peculiar phenomenon being due to a high frequency, and that Ohm's law does not hold perfectly true for currents of high frequency."

The following statements are made by Prof. Silvanus P. Thompson, F. R. S.

"Unfortunately, having to be absent from London attending a funeral on the very day of Mr. Tesla's lecture, I missed the great intellectual treat afforded to so many others. I can therefore answer your queries only from information received.

"1. Tesla's experiments so far as they relate to production of illumination in vacuum tubes that are disconnected or only connected by one electrode are due to effects of high voltage rather than to high frequency. It has been known for years that such effects could be produced on a smaller scale by the discharges of ordinary induction coils, with low frequency breaks, but of high voltage. Tesla has shown them on a larger scale, and, by using high frequency as well as high voltage, has made the effects not only much more brilliant but much more continuous. It must, however, be borne in mind that high voltage and high frequency are in many cases bound up in one another. If you drive an alternator at a higher speed, both volts and alternations go up.

"2. Do I consider that Ohm's law holds true for alternating currents? This is not a matter of my opinion or any one else's opinion; it is a question of fact. You might as well ask an engineer whether in his opinion the law of expansion of heat was true for liquids. It is not a matter of opinion at all. Ohm's law is certainly not true for alternating currents unless you take into account all the electromotive forces—those due to mutual and self-induction as well as that impressed on the circuit by the alternator. (See p. 629 of the fourth edition of my 'Dynamo-Electric Machinery,' 1892.) If you take all the electromotive forces into account and apply Ohm's law, then your calculations will accurately represent the facts. But if you leave out of sight these other electromotive forces and suppose that the E. M. F. of the alternator is the only one present, then it will be found that the calculation does not fit the facts.

"3. This reply answers the third question, whether the law applies also to high frequency currents. Certainly it does, if (and the IF is a big one) you apply in the calculation all the other electromotive forces of reaction that actually arise in the case. Ohm's law is only after all a statement of the proportionality which exists (and must exist) between an effect (the electric current) and its cause (the electromotive force). If you in your calculation leave out part of the cause the calculation of the effect will be wrong.

"4. You ask why enormous currents should not flow through Mr. Tesla's body when he touches the two terminals, which a moment before were at a difference of potential of thousands of volts? Please remember here, that in Tesla's apparatus—with an induction coil that has its secondary wires and its primary wires not in close geometrical relation, and not wound upon a common iron core forming a closed magnetic circuit—there is very great self-induction, and this, at high frequency, will produce a great reaction, precisely as self-induction does in the so-called constant current alternating current apparatus of Stanley. The result is that there will be a tendency to the production of a constant (small) value of alternating current—perhaps about $\frac{1}{1000}$ ampères—and certainly not a tendency to keep the volts constant. In this case Ohm's law should be used the other way round: $E = C R$. When there is nothing across the terminals, R is enormous,—so is E. When you join the terminals with the hands or with a copper wire R is small, and E therefore becomes small also.

"5. Lastly, you ask why the current does not rise to very high values when the volts rise to high values? This is a simple result of the reaction due to self-induction. When the current rises, even a very little, it sets up reactions of an electromagnetic nature which produce counter electromotive forces, and therefore the volts literally are not so high. I doubt if the volts from one of Mr. Tesla's hands to the other, while he was touching the terminals, were as much as 200 volts; the current through his body, small though it was, damped down the volts. Remember, that at high frequencies every inch of straight wire will act as a 'choking coil,' and may produce relatively as great an effect as Elihu Thompson's choking coils do in his low frequency currents, which he uses for electric welding."

Mr. W. Taylor, of the firm of Harrow & Croydon, has made some very interesting experiments with alternating currents of different frequencies, and the following are the statements he makes regarding the subject in question:

"Not having had the opportunity of investigating Mr. Tesla's apparatus, I am unable to say absolutely to what the results are due, but a number if not all of the effects he produced may be obtained without the high frequencies which he used.

"I consider that Ohm's law does not hold good for alternating currents as well as direct. Ohm's law is only true for what may properly be called ohmic resistance, *i. e.*, resistance measured as usual with a bridge, continuous current and galvanometer; nor does it hold good for high and low frequencies. In both these resistances there is an increase in apparent or virtual resistance.

"In Tesla's experiments the frequency is undoubtedly the main cause which prevents the passage of currents at high voltages. The absolute capacity of the apparatus may, however, have something to do with this.

"The virtual resistance of a wire subjected to the passage of an alternating current is subject to two influences, the frequency and the diameter, and a constant also comes into consideration, depending on the position of the conducting wire. This must be added to the ohmic resistance. The greater the diameter the greater the frequency, the greater the virtual resistance.

"I consider that when speaking of a conductor or wire subjected to alternating currents, the measurement of resistance should universally be divided into three parts: (1) Ohmic or true resistance, due to conductivity alone; (2) Inductive resistance in the wire itself; (3) Inductive resistance due to the position of the wire. By the time electricians understand the true theory of dielectrics, we shall not improbably have many more experiments carried out of such truly scientific value as those of Oliver Lodge and Lord Rayleigh."

The following opinions were given by Mr. C. H. W. Biggs, editor of the *Electric Engineer*, of London; Edouard Hospitalier, Redacteur en Chef de *L'Industrie Electrique*, of Paris, and W. J. Hammer, of New York City.

C. H. W. Biggs, Esq.:

"I should not like to express a definite opinion as to the cause underlying Tesla's experiments, as sufficient time has not elapsed to allow me to study his results as I should wish; in fact I am waiting for his written paper to be published by the institution before attempting to decide the cause of the phenomena.

"2. I hold most emphatically that Ohm's law is true under all circumstances, electric or magnetic. It has been one of my aims in life to try and get folks to believe in the circuits and its interactions as sufficient to explain all the phenomena presented to us. If we accept the theory of the circuit we have to accept the idea of three dependent quantities: pressure, resistance and resulting effect; whether we call that current in a conductive circuit or lines of force in the magnetic. If resultant effect is not directly as pressure and inversely as resistance, then nature has produced an abortion, which I cannot believe. Ohm's law holds good not only in electric matters, but in every analogous branch of science with which I am acquainted, be it hydraulics, pneumatics, heat or sound."

Edouard Hospitalier, Esq., Paris:

"I believe Mr. Tesla's experiments give us many phenom-

ena which are only to be produced by currents of high voltage and high frequency. Ohm's law holds perfectly true, but all of the actions must be taken into account, including self-induction, electrolytic actions, ohmic resistance, etc. It is certainly true that the 'skin effect' applies in this case, as shown by the experiments of Lord Kelvin (Sir William Thomson). In a cylindrical conductor, with a continuous current or an alternating current of very low frequency, the whole of the wire is used to conduct the current. As the frequencies become higher the central portion of the conductor carries little or no current, until at very high frequencies the skin effect is produced, and only the very outer skin of the conductor carries the current.

Lord Kelvin (Sir William Thomson): "I did not see Tesla's experiments, my duty having kept me in Glasgow. I have been informed that they included currents of moderate frequency, such as 14,000 and also of much higher frequencies, which I believe caused many of the astonishing phenomena."

Mr. W. J. Hammer, of New York City, says: "If, as it has been stated, a saw moving fast enough could cut off a limb without pain, rendering the use of anæsthetics unnecessary; if our ears cease to hear sounds produced by insects whose rate of vibration are above a certain amount; if a platinum cauterizing wire is not painful where the heat vibrations raise it to white heat, although at a dull red, and a consequent low rate of vibration, it is very painful; if the violet end of a spectrum, with its high rate of vibration, is not as painful to the eye as the colors lower down the spectrum of lower rate, is it not reasonable to suppose currents of exceedingly high frequency will have no effect upon the nervous system, although those at lower rates may produce serious results?"

Electro-Metallurgy.—I.

BY F. M. F. CAZIN.

The acquirement of knowledge by personal observation in all matters belonging to electro-metallurgy has so far not proven to be within easy reach, because establishments practicing this branch of metal production, or of refining, parting or plating have found it to be in their commercial interest to keep their doors closed to all outsiders, almost without exception.

The practice of excluding professional observers at all events was adopted at the very beginning by the pioneer establishment at Oker, and it was adhered to at Hamburg, the other German establishment in this line, and it was followed at Casarza, in Italy, at Pont St. Martin, in France, and at Stephans-Huette in Upper Hungary. If on this continent the very few establishments now active in the important branches of silver parting or copper refining, or even plating, follow a different policy, the fact has not become known to me.

So far all information obtainable had to be acquired by study and stratagem. And nevertheless this branch of metallurgy has acquired such practical importance, that the author needs no other justification than this one for his attempt to report results and to state the scientific theories on which they were built and on which further progress must be made.

1. HISTORICAL.

Some sixty years have now passed since Antoine Cesar Becquerel was made a member of the "Academie des Sciences" in acknowledgment of his researches made and of his results obtained in electro-metallurgy. He calcined ores to chloridize or sulphatize their metal contents, dissolved the metal compounds obtained and subjected the solutions to electrolysis.

Some forty years have passed since the same savant, jointly with his son Alexandre Edmond, published (1849) their memoirs on the laws that govern electro-chemical decomposition, there existing the strange coincidence in this case, that at the very same time a direct descendant of the Empress Josephine (de Beauharnais) of France, the Duke Max, of Leuchtenberg, also published his theoretical researches in the same field, calling attention to the industrial importance of his observations and results in parting the finer metals from their alloys with lower metals.

And some twenty years have passed since Elkington for the first time made a practical industrial use of the discoveries made by the savants just mentioned. He erected works for the treatment of black, white and blue copper, and treated these intermediate furnace products between ore and ingot successfully; but his method remained a secret, and though imitation was in his time attempted at many places, the defective state of both electrical knowledge and electrical apparatus caused failure in every attempt but his, and such imitation succeeded only at a much later date, when both electric and chemical science had much advanced, and when dynamos were constructed producing currents of the required power and modification.

In the matter of parting bullion containing silver and gold Wohlwill, of the Hamburg Affinery, was successful, producing electrolytically both metals in a fineness until then not attained in common parting practice; and B. Moebius invented (1884) and introduced first into American practice an improved and superior silver parting process and mechanical contrivances in connection therewith, which render it possible to part doré bullion of required fineness at the low cost of one-sixth of one cent per ounce. But the difficulties met with in treating fine metal bullion are not so manifold and serious as those which turned up on all sides when the electrolytic production of metallic copper from higher and lower unclean furnace products or even from ores was attempted. Nevertheless Braeuning, of Oker, Marchese of Lombardy, and especially Siemens & Halske, of Berlin, have achieved results in this direction which are destined to entirely change copper production from its present basis with the exception of such processes as are the result of treating rock which contains the metal in its free state. Although in North American copper production such exception covers the larger part of the total product, the larger part of the copper product of the world is made from pyrites, to which the new electrolytic process is applicable.

To Messrs. Siemens & Halske it is due, in part, that methods and results have become accessible to a certain extent.

On this continent a few establishments for electrolytic treatment of doré bullion, of copper matte and for plating have been in operation for a short time, but as yet none exists for the treatment of crude copper ores, which at present has become a practical possibility, having been tested on a large scale, and by which treatment the cost of production is so much reduced, that aside from its simplicity its introduction on the North American Continent is one of the things that can be clearly foreseen.

In the treatment of lead bullion for the separation of silver from lead, Keith, of New York, opened the road, and Blas, Miest and Letrange extended their labors to the electrolytic treatment of lead ores and to the production of zinc by this process.

The latest achievement in this line consists in a practical economical electrolytic precipitation of metallic iron from its ores, and a practical production of copper directly from its sulphides by the use of a solvent produced and regenerated continuously by the process.

If European savants and professionals have developed science and art in the line of wet electro-metallurgy, Americans have created dry electro-metallurgy. This is the electrolytic treatment of metalliferous solid com-

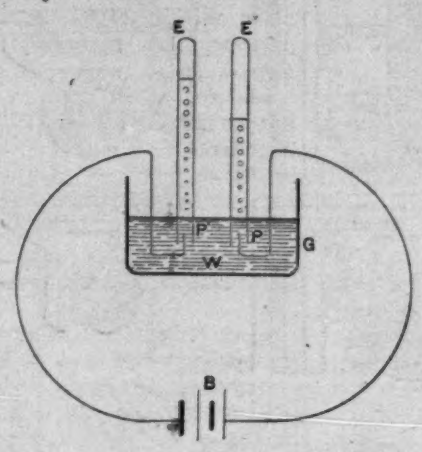


FIG. 1.—ELECTROLYTIC APPARATUS.

pounds, when made liquid by heat, especially for the production of aluminium.

As in all other branches of human activity, the progress made in this second half of the nineteenth century has been great and rapid in theoretical and practical electro-metallurgy, and yet there is much new and untouched ground left in this field.

There is an evident call for the electrolytic treatment of both silver and gold ores, the present metallurgical methods being very defective either in simplicity of operation or in the beneficiation of a sufficiently high percentage of the metal contained in the ores.

The author desires to smooth the road to further progress in this and other matters of electro-metallurgy by his present treatise, successful invention in this line being both interesting and profitable.

While there is an abundance of literature covering the different functions of electric energy, such as transmission of power and lighting, the metallurgical field of electric usefulness has so far been thoroughly neglected by authors, and the reason therefor lies in the difficulty under which all reliable information in this line must be obtained as yet. The practical importance of the matter justifies the attempt to here collect all information that is available, though the collection may possibly not be absolutely complete when accomplished.

2. WHAT ELECTRO-METALLURGY IS.

Until the utilization of the electric current became one of the many processes of metallurgy, these processes were either of a mechanical or a chemical nature. In all cases of the first kind a division is made by mechanical contrivances between different sorts of minerals occurring in the same ore, the product being called concentrates. In all cases of the second kind chemical affinities are taken advantage of. These processes were called wet or dry, the former when solution in water or in a watery solution is made part of the operation, and dry when melting or smelting is resorted to. Of all the chemical metallurgical processes, it is characteristic, that other matter is brought into reaction with the ore, which is treated, for bringing about a combination between such foreign matter and the matter, by which the metal is mineralized in its natural ores. No case was known in which the mere application of mechanical force (kinetic energy) could dissociate any metal from its components in the manner, in which the elements of explosives dissociate, and but very few cases exist in which the application of heat (caloric energy) alone is successful in such dissociation.

When it had become known, that chemical reaction produced free electric currents, and that under the influence of the electric currents chemical compounds could be disunited into their components, the quantity of copper so disunited under precisely defined conditions becoming a unit for measuring one of the factors of electric energy (ampère), it was but a short step to the conclusion that the electric currents could be made available for practical metallurgical purposes. And so important has the application of the electric energy to such practical metallurgical purposes become, that we may now properly speak of electro-metallurgy as a special branch of general metallurgy.

In this connection it is worth mentioning that it is not exclusively by its faculty to disunite chemical compounds that electric energy has proven as of the very highest value in metallurgical operation. The practical possibility of modifying the kinetic energy, becoming free in the gravitation of water, into electric energy, and of converting such electric energy at a considerable distance back into kinetic energy, thus substituting the employment of fuel, which otherwise would have to be used in the production of such kinetic energy through the intermediate production of heat (caloric energy), this practical possibility has given, in mining and metallurgical business, an importance to electrical appliances in general which theretofore was possessed by fuel and its application only.

At this date electrolysis is in metallurgical practice carried out in both wet and dry processes; this is in using solution in water as well as the liquefying by heat as contributive action to the process.

As in all other metallurgical manipulations, electrolysis is but rarely employed exclusively in the production of any metal; but, as any given case may require on account of greatest economy, it is grouped with other metallurgical operations to a total system of action tending to the one desired object. To properly select and arrange such a system must in all cases be a matter of determination by experts in both metallurgical and electrical matters.

Electrolysis achieves two important results, which were not attained by older methods, namely:

1. The disunion of metals out of their compounds without the assistance of foreign matter for forming new (waste) compounds.

2. A purity of metallic product not attained by other methods.

In such achievement advantage is taken of electric currents resulting from modification of energy, as it appears either in chemical affinity, or in heat, or in motion of matter—that is, as galvanic electricity, or as contact electricity, or as magneto-electricity, each of these modifications possessing its special interest to the practitioner of the art of electrolytic treatment of metals.

Galvanic electricity is made use of in the measurement of electric energy as well as in assays and analysis.

Contact electricity is directly and immediately taken advantage of in electrolysis.

Magneto-electrolytic energy is made to serve in dynamos for the conversion of kinetic energy into electric energy.

If, therefore, a definition of what electro-metallurgy is should be given, it may thus be expressed:

Electro-metallurgy is the art of producing, refining, separating and plating metals through the instrumentality of an electric current, and of producing an electric current by the chemical reaction of elements, of which one is a metal or a metal compound.

3. ELECTROLYTIC TERMINOLOGY.

I have assumed that the readers of this series possess the knowledge, not only of all the main laws so far known in science as governing electric energy, but also of what relates to the conversion of one class of energy into another class of energy, and of all that relates to the equivalence between the different expressions of energy, and of the assumption that all classes or modifications of energy emanate from one and the same source, which source we more and more learn to consider as "Space."

Therefore, the specific terminology of electrics in general is assumed as known, but electrolysis has yet a special terminology of its own, and on it I must agree with my readers before entering on technical discussion in regard thereto.

In general electrics it has been agreed to assume that there be in the electric current a direction of flow, and that this direction be from positive to negative pole, and to this assumption electrolytic terminology accommodates itself, the pole being called the positive pole, at which the kind of electricity is prevalent that is produced by friction between glass and leather covered with zinc-tin amalgam.

Any matter attracted by the positive pole is called negative matter and all matter attracted by or set free at the opposite or negative pole is called positive matter.

Reference is made to the apparatus shown here for electrolytic disunion of water as an illustration of the terms to be used.

The decomposing action of the electric current when resisted by chemical affinities is called *Electrolysis* (Elysis*) the liquid (*W*) is called *Electrolyt* (Elyt), the submerged ends of the electric conductors, that is, the poles marking the interruption of current in the Elyt are called *Electrodes* (Edes). The electric current is assumed to overcome the

*Abbreviations and symbols are shown in parenthesis.

resistance offered by Elyt in a direction leading from the positive pole (P') to the negative pole (P) and the positive pole (P') (where oxygen develops) is called *Anode* (+ Ande) and the negative pole (where hydrogen develops) is called *Cathode* (—Cthde). The divided matter at the + Ande (oxygen) is called *Anion* (—Ann) and the divided matter at the Cthde (hydrogen) is called Cation (+ Ctn).

4. ELECTROLYTIC CALCULATION.

Even the only science which has a right to claim absolute "exactness" for its conclusions must admit a dependence of the correctness of these conclusions on the preceding correctness of fundamental values, equations or axioms, a fact to which Professor Huxley gave expression when he stated: "The mathematics may be compared to a mill of exquisite workmanship which grinds you stuff to any degree of fineness, but, nevertheless, what you get out depends on what you put in." And up to this very date the controversy is not ended even as to the best unit for measuring distances. The only such rational unit in present use, the English yard, representing the length of the pendulum vibrating seconds in vacuo in London, at the level of the sea, has been lost sight of, because its use was neither made to conform with the generally accepted arithmetical system of reckoning with powers of 10, nor was it developed into a system, in which the values for volumes and weights are interchangeable, as we find both such conditions in the combined decimal and metrical system. But the controversy is continued, whether future generations will rationally reckon with a unit of distance derived from the light wave and with powers of 12, or with a unit $\left(\frac{g}{2}\right)$ derived from the distance of free fall during the first second and with either one or the other of arithmetical systems.

If this be so with the oldest and most exact of sciences, who would be audacious enough to claim that at this date electricity has passed its final decisions on the form of its units and of its equations. But such as they are, we have to accept them for the purpose of describing an actual state of affairs, in which electrical values are implicated.

The most important units and their relation is thus expressed (Ohm's law):

$$1 \text{ ampère (current)} = \frac{1 \text{ volt (E. M. F.)}}{1 \text{ ohm (resistance)}}.$$

The unit of current (ampère) was determined by its chemical action and established on the quantity of copper (0.0003316 gr.) deposited from copper sulphate ($Cu\,SO_4$) per second. The unit of resistance (ohm) was originally determined by the length of a conductor and established on such length of 1.0624 m. of a mercury conductor of a transverse section $= 0.001^2$ metre.

The unit of electromotive force was determined by both current and resistance, and established as their product in the equation.

1 volt (E. M. F.) = 1 ohm (R) × 1 ampère (current).

In transforming electric values into mechanical values we have to make use of the well-established equation, by which equivalents for electric and kinetic energy are shown, namely:

$$\text{Kinetic energy} = \frac{\text{volt} \times \text{ampère (watt)}}{g} = \frac{\text{watts}}{9.81} \text{ kgr'ms.}$$

And in consequence their conversion into horse power by $\frac{\text{watts}}{9.81 \times 75} = \frac{\text{watts}}{735.75}$ for metric h. p., or $\frac{\text{watts}}{745.94}$ for English h. p.

If thus we have established the electric and kinetic equivalents of energy, it must not be lost sight of, that there is experienced in the practical transmutation of mechanical power into electrolytic effect an actual loss of electrolytic effect, which is believed to have aggregated in the as yet imperfect apparatus employed as 33 per cent., which loss represents such portion of mechanical energy as is simultaneously transformed into other energy, such as specific (latent) or even free thermable heat, therefore the actual effect of mechanical horse power applied amounts to only 62 per cent. of the electrolytic energy when calculated on the basis of the caloric effect, which is equivalent to either.

At present we have to accept for electro-metallurgical practice the stated experimental result, that $0.62 \times 736 = 456$ volt ampères (watts) can be produced per metric horse power, and that practically $\frac{736 \times 0.000136}{456} = 0.002$ metric horse power will produce one volt ampère (watt).

A still more striking illustration of the discrepancy between theoretical effect and practical result in the transmutation of energy from one class into another is then made, if we further consider the use of coal for producing these 0.002 h. p. per volt ampère (watt).

The theoretical caloric effect per kilogramme of carbon is as 8,080 calories. It must be an excellent coal that contains sufficient carbon to produce 7,500 calories per kilogramme. Steam engines require from 12,000 to 15,000 calories per hour and horse power, which would theoretically require two kilogrammes of coal per hour. But the boiler as commonly used produces only 6 per cent. of the theoretical effect, or $\frac{6 \times 15{,}000}{100} = 900$ calories from two kilogrammes of coal per hour, and of these 900 calories only 80 per cent. become effective in the engine, or, $900 \times \frac{8}{10} = 720$ calories from two kilogrammes of coal. And if we assume, that the dynamos produce 80 per cent. in electric energy of the kinetic energy by which they are driven (moved) their effect pro rata amounts to $\frac{720 \times 80}{100} = 576$ calories per two kilogrammes of coal, and the real effect as compared with theoretical effect of these two kilogrammes of coal is only as $\frac{576 \times 100}{15{,}000} = 3.84$ per cent., calling for $\frac{2 \times 100}{3.84} = 52.0833$ kilogrammes of coal per hour and horse power, all of which tends to show how little is being achieved in the way of beneficiating the caloric values of coal, and how much might be achieved by more directly converting it into electric energy, serviceable for metallurgical and other purposes.

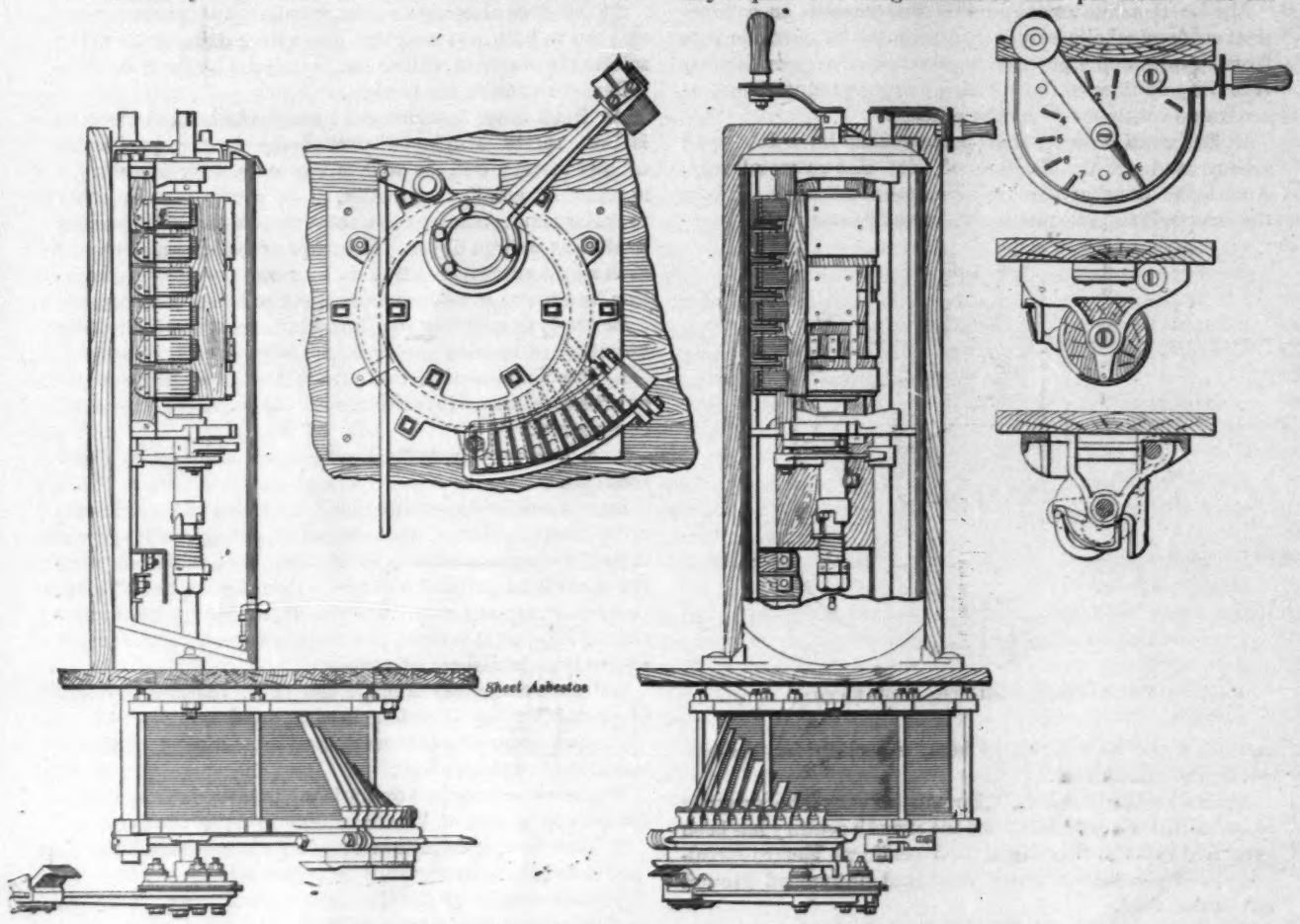


FIG. 1.—COMBINED RHEOSTAT AND PLATFORM SWITCH.

Pole Indicators.

L'Electricien is responsible for the following recipes for pole indicator solutions. For placing inside a glass tube corked at either end and provided with adjustable electrodes: 50 grammes of glycerine, 3 grammes of saltpetre, 20 grammes of water, 0.5 gramme of phenol phtalein dissolved in 10 grammes of alcohol. The *negative* pole is surrounded on the passage of a current with a violet-red aureole. Paper cut into short strips may be used as pole indicators if dipped into a bath composed of 250 grammes of saltpetre dissolved in a litre of water (8¼ ounces to 1 quart), then dried, and finally soaked in a solution of 5 to 6 grammes of phenol phtalein dissolved in alcohol. If the last treatment is replaced by any of the following, we get the results set forth:

	Coloration.	Pole.
Rosalic acid (neutralized)	Violet.	Negative.
Methyl violet	Blue green.	Positive.
Tropæolin OO, or orange No. 4 of Porier	Bright red.	Positive.
Orange No. 3. (These two have a dipehnyl-amine base)	Bright red.	Positive.
Orange No. 1, or No. 2 (naphthol base)	Red.	Negative.

Litmus paper can also be made use of as a pole indicator.

Methods of Electrically Controlling Street Car Motors.*

BY H. F. PARSHALL.

While in many respects the controlling apparatus for street car motors and the general requirements of the same do not differ greatly from some other cases, there are some features that demand the closest attention if the car is to be handled either efficiently or comfortably so far as the passengers are concerned. While the number of methods proposed and tried in times past has been great, at the present time there seems to be sufficient agreement between the principal designers and sufficient data at hand to warrant the writing of a fairly comprehensive paper on the subject.

The problem of controlling the motors is probably the most difficult one in the whole range of street car work, and in no small degree determines the electrical design of the motors, or, to be more specific, to start a car under any given conditions of track a certain torque is required. Beyond a certain limit, fixed largely by the convenience of passengers, this torque cannot be exceeded. The smaller the current with which the motor is able to develop this torque the smaller the rheostat or other starting devices may be and the more efficient the car equipment. Should the motor, therefore, be incapable of developing a comparatively powerful torque per ampère, the amount of energy dissipated either in the magnetic windings, armature windings, or rheostat becomes excessive, the results being the more or less rapid deterioration of these parts.

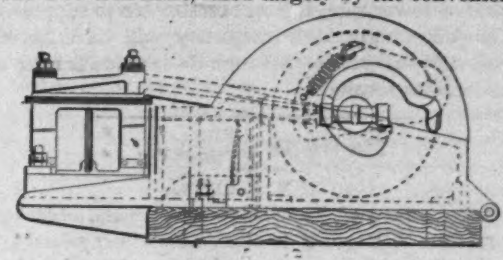


FIG. 4 B.

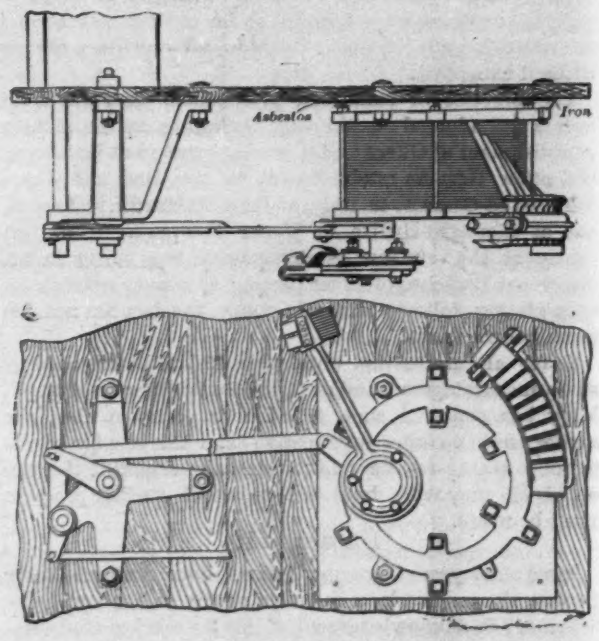


FIG. 3.—DETACHABLE RHEOSTAT.

It may not be out of order just here to discuss the design of the motor with reference to getting this torque most efficiently. The average horse power exerted by a street car motor at the car wheel probably does not exceed 20 per cent. of the maximum it is expected to do in starting the car under the various conditions encountered. Now to get the highest efficiency from a motor run under these conditions it is necessary to get the highest possible efficiency at that horse power at which the greatest amount of work is to be done, and inasmuch as the loss in the conductors for this average horse power is necessarily low (otherwise the motors would burn out in doing the maximum work to which they are subjected), the question does not resolve itself into how to get the least possible motor resistance of armature and magnets, but rather how to minimize the constant loss of hysteresis, eddy currents and friction. While all of these losses vary somewhat with the speed in series wound motors, the variation of these losses is not great, since for an increased speed there is in general a diminished intensity of magnetization and pressure. To render these losses a minimum, and at the same time to get the requisite torque to handle the car efficiently, there is but one solution, that is, to put the maximum number of turns on the armature compatible with good running as to heating and sparking

While the truth of these statements may be more or less apparent to all when stated in plain terms, but little atten-

* Read before the American Institute of Electrical Engineers.

tion was paid to this matter in the earlier motors designed. The numerous measurements made, however, have so uniformly been in favor of motors with comparatively a large number of conductors on the armatures, that the importance of this matter is now pretty generally understood. This agreement as to the general design of motors has in no small way been influential in bringing electricians into agreement as to how the motor should be controlled, since with an armature of a comparatively large number of turns less turns are required in the field magnets to produce a given torque with a given number of ampères. The function of the magnets, therefore, has become of less importance. It is always, however, to be borne in mind that, other things being equal, the motor with the greatest number of turns in the magnets will develop the greatest torque for small currents. With a given E. M. F. acting on the armature circuit, and a given torque developed by the armature per ampère, it does not matter, so far as efficiency is concerned, whether the difference in E. M. F. at the armature terminals and the line is due to drop in external resistance or to drop in the magnets. This point determines once for all that motors with commutated fields are not necessarily more efficient than other motors.

The particular advantages of the commutated field method are, that with a limited number of pounds of copper, or in the case of street car motors with the limited space available for field magnet windings, it is possible to adjust the magnetizing force of the field coils so that the rate of doing work of the motors may be made to correspond with the rate this work is required by the car for the various speeds and conditions of track. This adjustment may be made for any size of motor with any required degree of precision by varying the number of magnetic coils. To increase the range or precision it is only necessary to increase the number of coils. In practice it has been found that this number could not be very great, otherwise the car wiring becomes too complicated and too expensive. This same holds true of the controlling switch. Three magnet coils or sets of magnet coils seem to be the practical limit, since there is a general agreement between street railway managers that the present number of magnet connections (6) should not be increased, and even with this number there is occasional trouble with broken wires or terminals. With a 15 h. p. motor it is possible with three sets of coils to run under most conditions met with in practice without employing external resistance. It is occasionally necessary, however, when the car is to be run at two or three miles an hour, to make use of the resistance coil that is ordinarily used only when starting. With 25 h. p. motors it is necessary, with three sets of magnet windings, to make use of this resistance coil very considerably in ordinary practice, since without this it is not possible to get a speed of less than one-third the maximum speed of the car, which is generally taken to be about 18 miles an hour.

The range of speed without the use of a rheostat is determined by the limit to which it is safe to heat the magnets. The temperature of the magnets should not in any case exceed 65 degrees C. This would put the increase of temperature at about 30 degrees C. This increase corresponds to an average loss in the magnets of about 0.3 of a watt per square inch of radiating surface. For the few seconds generally taken to start the car the loss may be as high as two watts per square inch without dangerous heating. Experience, however, has demonstrated that to exceed this limit, even for very short periods, there is considerable risk. Having the maximum number of watts that may be dissipated in the magnets, the series resistance of the same may be calculated from the properties of the motor on the supposition that each ampère taken by the motor produces a certain number of pounds pull at the periphery of the car wheel. In a well designed motor with commutated fields it is easy to get from 35 to 40 pounds pull at the periphery of a 30-inch car wheel with the coils in the series position. These coils are either wound side by side or one on top of the other, according to the necessities of the case as determined by the general design of the motor. Experience has shown the advisability of winding these coils in independent spools whenever the general design will permit, since, in case of trouble, it is cheaper and easier to replace the damaged coil, and there is less liability of crosses between the coils. As an example of a design that has been found to give general satisfaction in practice, I give the following figures from a series of tests made on a Sprague No. 6, S. C. motor, the magnetic data of which has already been published by myself:*

EFFICIENCY OF STREET CAR MOTOR NO. 6.

Brake h. p.	Efficiency.	Speed.	Remarks.	Res.
	Per cent.			
14.3	87	1,110	3 coils in parallel.....	0.8
11.8	87	1,174	3 " "	0.8
11.4	86	1,184	2 " "	1.4
9.0	84	1,309	2 " " ...	1.4
8.25	82	955	2 in parallel, 1 in series.	3.24
6.35	79	1,040	2 " 1 "	3.24
4.9	72	1,070	2 coils in series	4.86
3.9	70	1,014	3 " "	7.42

It is to be noted especially that it is possible to get an approximately constant speed with a wide range of loads and yet have the energy dissipated in the magnets remain approximately constant, and that it is possible to get a torque corresponding very approximately over a wide range to that required to propel a car under conditions met with. This is the solution of the question, how to get the highest efficiency. For instance, suppose a car is to be run between two points in a given space of time, and this is not an infrequent requirement, and that the magnet windings of the motor are such that either the car runs the distance in too short a time or in too long a time. It will be necessary then to accelerate the car for a time beyond the limit required, then to allow it to slow down, then to accelerate it again, or go through some such cycle of operations to get the required results. More power will be required with such windings than when such a torque can be had at the motor as will produce the required speed by an approximately uniform acceleration. To get the same results given above for the No. 6 motor, with the magnet coils arranged in loops instead of separate coils, would require upward of three times as many pounds of copper as was used in the present case (110 lbs.). This motor was designed to give a maximum car speed under ordinary conditions of from 12 to 15 miles an hour. At present it is thought advisable to have a maximum car speed of from 18 to 20 miles an hour,* since numerous measurements have shown the economy of running street cars at as high a speed as the conditions of track, etc., will permit. In a series of measurements made by myself, it was found that the watt hours per car mile decreased very considerably with the speed of the car up to 30 miles an hour. To get this high speed (20 miles per hour) it has been found necessary to vary the proportions of the magnet coils from that given in the above for the No. 6 motor. Thus for a single reduction 15 h. p. motor the resistance of the last coil to be turned from series to parallel is only 15 per cent. of the total resistance of the magnets, and the turns of this coil only 20 per cent. of the turns in the other two coils. The reason for putting this low resistance coil inside is to get the greatest number of turns when the coils are all in series, and the least resistance when the coils are all in parallel. Further, under ordinary conditions this coil has the least expenditure of energy in it, and the least radiating surface. With a winding of this proportion it is necessary with 15 h. p. motors to use an external resistance of 6 or 8 ohms. With 25 h. p. motors an external resistance of from 10 to 12 ohms is required. This resistance should be so subdivided that there is not more than 20 volts E. M. F. between adjacent contact pieces, and so proportioned that the increase of temperature is not in any case above 150 degrees C.

A method that is receiving a great deal of attention now is that known as the "series parallel method." While it has not yet been introduced very largely in practice, numerous experiments have indicated the desirability of

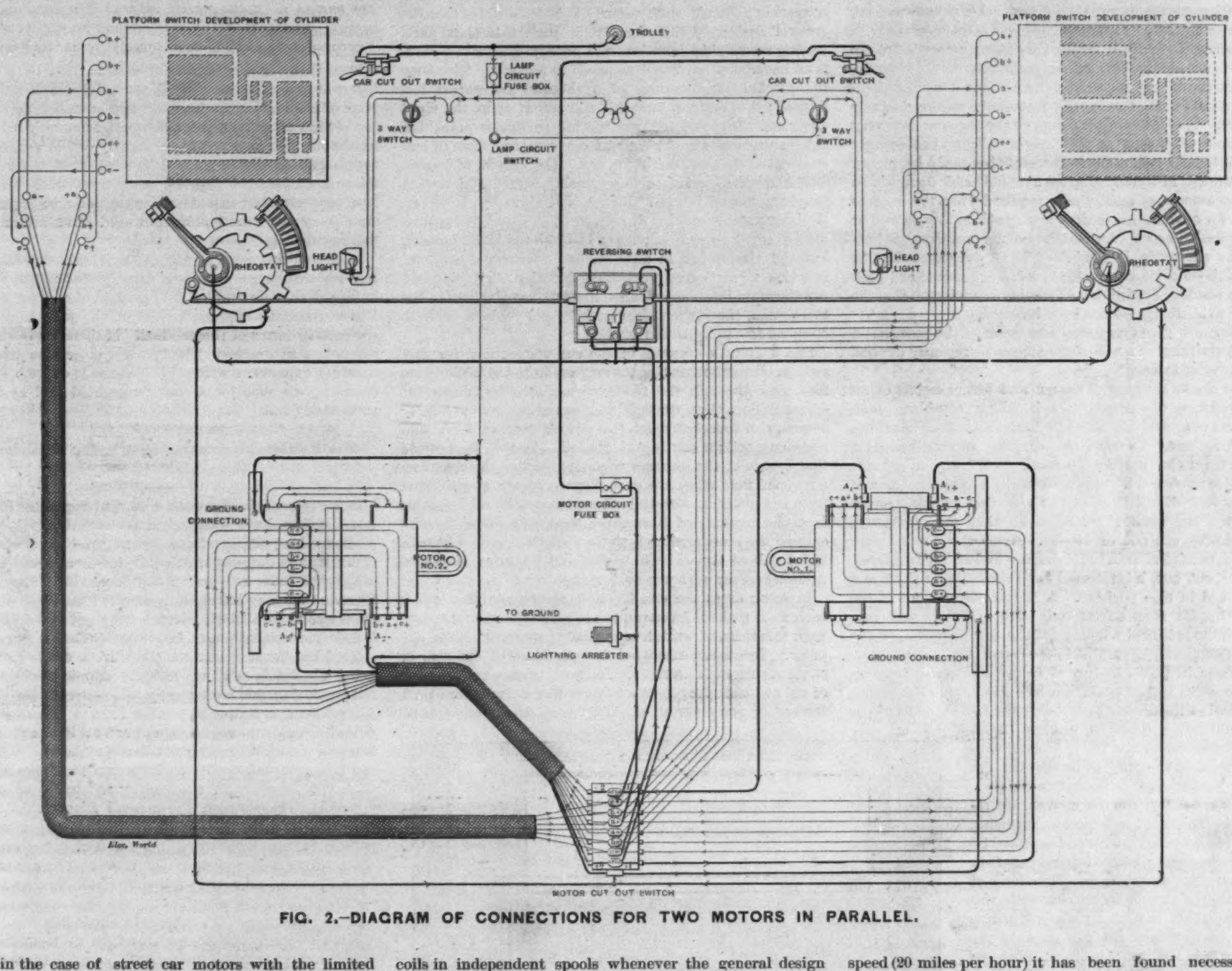


FIG. 2.—DIAGRAM OF CONNECTIONS FOR TWO MOTORS IN PARALLEL.

* Transactions, vol. VII., p. 218.

*All car speeds are quoted for straight and level tracks. These, when calculated for a new motor, are determined from the speed and horse power curve of the motor, assuming the resistance to be 30 pounds per ton. The methods of measuring these speeds are, in general, such that the probable error is too great to determine the percentage slip of the wheels.

doing this as soon as some of the troublesome features of the switch have been overcome. The method of operating is a sfo

In starting, a rheostat of from 8 to 20 ohms is used, according to circumstances, in series with the motors, which are in series with each other. After this resistance is thrown out of circuit the magnet coils of one of the motors are short circuited, a section at a time. To make the start smooth, three or four coils at least are required. The magnet coils being short circuited, the armature is then short circuited, and the magnet coils thrown into circuit simultaneously with the armatures being thrown in parallel. It is just at this point where the difficulty with the switch has been encountered, since either the switch has to be operated with great rapidity or the contacts act in perfect unison, otherwise unpleasant results as to short circuiting occur.

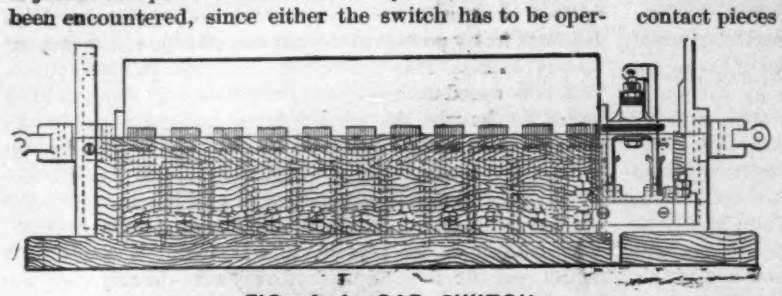


FIG. 4 A.—CAR SWITCH.

The advantages of the method are that a very wide range of speeds are obtainable at a comparatively high efficiency, and that the energy required to be dissipated by the rheostat is small for the low speeds frequently required in city practice. This lessening the duty of the rheostat is a very important point, since as yet it has been found exceedingly difficult to construct a cheap rheostat that could be placed under the car in the small space available and dissipate so large an amount of energy as is required when the car is to be run for a considerable time at a speed as low as two or three miles an hour. Any method of control that has lessened the energy to be dissipated in the rheostat has, in general, been considered with favor, since there has been a corresponding diminution of trouble in each case that the energy to be dissipated has been lessened.

Having now given a general discussion of the problem, a brief description of some of the apparatus recently devised may prove of interest.

Fig. 1 shows the general design and arrangement of an improved form of platform switch, which combines both the "field commutation" and the "series resistance" methods of starting cars. To start the car, the switch handle is turned from the position marked "off" with a counter clockwise movement. This movement carries the arm of the rheostat, which is placed under the switch, around and over the contact segments, so that the resistance is gradually cut out of circuit. After the contact arm has been carried around to 135 degrees and all the resistance has been cut out, it is released from the cylinder shaft and left locked in this position. A further movement of the switch handle then affects only the cylinder, and commutates the sectional windings of the field magnets of the motor from series to parallel in the usual way. In stopping the car the field coils are turned from parallel to series, the resistance coil is then again put into circuit and the circuit broken when the contact lever leaves the last segment of the resistance coil, and not, as hitherto, upon the cylinder contacts. The only caution to be observed in stopping is to see that the switch handle shall be turned to the position marked "off," for the motors are reversed by means of a separate reversing switch placed under the car and operated by a lever connecting with a separate shaft in the controlling switch case. The shaft of the platform switch interlocks with this reversing shaft in such a manner that it is impossible to reverse the motors until the cylinder is in the "off" position. The use of this separate controlling switch has been objected to, but to combine both the advantages of the rheostat and commutated fields the switch mechanism becomes too complicated and the switch too large to have the reversing performed by a reverse movement of the controlling switch handle.

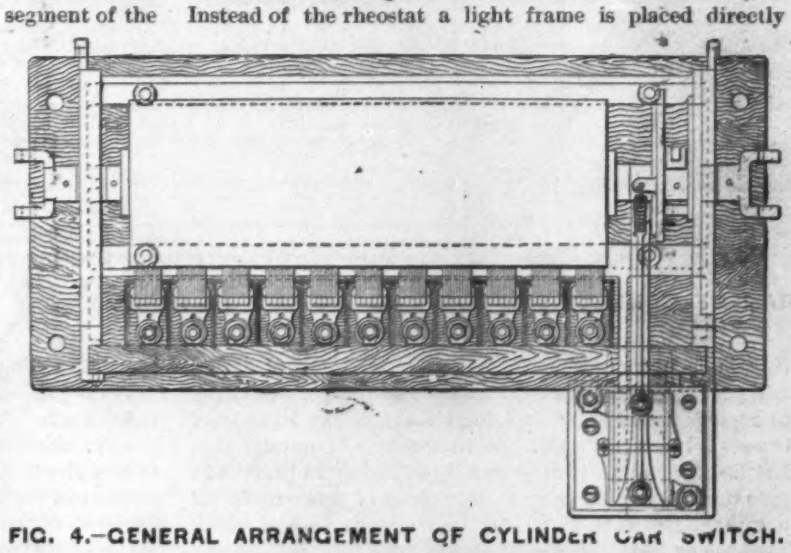


FIG. 4.—GENERAL ARRANGEMENT OF CYLINDER CAR SWITCH.

The cylinder plates and contacts are made of thick iron stampings, as experience has shown that iron is more durable than brass for this purpose. The burning, due to the formation of arcs, does not have so much effect upon iron as it does upon brass, and there is more certainty of good contact. The contacts on the cylinder consists of a number of stampings arranged in a brass frame, each stamping making an independent spring contact with the switch cylinder. The rheostat employed is built up in a circular form from a large number of flat rings stamped from thin iron sheets. The rings are built up in the form of a cylinder, each ring of iron being separated from the adjacent rings by a ring of mica, except at the one point where it makes contact with the next ring. Instead, however, of being arranged in a continuous spiral circuit, the coil is divided into a number of parts so arranged that the direction of rotation of the adjacent spirals is reversed, this being done to make the inductance of the coil as small as possible. A coil wound up in a continuous spiral having a mean diameter of 12 inches and a radial depth of 1 inch, 6 inches long, and composed of 400 plates, was found to have an inductance of 40 millihenrys. The coil was then wound up in 12 sections, the direction of each section being reversed, and the inductance in this case was found to be 8.5 millihenrys. These sections are stamped from different thicknesses of metal, so that those coils which are in circuit the shortest time and have the least current to carry are of highest resistance and least ampère capacity, and those that are liable to be in circuit for some time are thicker and have less resistance and greater ampère capacity. Copper connections are made at different points in the coil, all these connections being brought to a number of small iron contact pieces fitted in a spiral form and arranged so that the switch contact lever can slide over them. The contact pieces are insulated from the frame with sheet mica and from one another with small slate slabs. The rheostat is entirely fireproof and can expel with safety the heat evolved within it under all ordinary conditions. As a point of practical importance it is, however, advisable to place a sheet of metal and a layer of asbestos paper between the rheostat frame and the car floor. This will prevent any danger from fire, either from heating or sparking, should such occur. It is to be noted that the general design of this rheostat is such that those parts having mechanical functions and energy dissipating functions have been separated as much as possible. Of course the mechanical functions of a rheostat are more or less limited; it is evident, however, this effort is in the right direction. It is with respect to this particular point that the rheostat has a decided advantage over any form of mechanical clutch in starting a car. The clutch, of course, has its advantage in starting quickly bodies that have a great amount of inertia. In ordinary practice, however, the amount of energy dissipated in a clutch is approximately equal to that necessary to dissipate in a rheostat, but the clutch has in addition to its energy dissipating function a very exact mechanical function, and these two functions are interdependent on the same wearing parts. For this reason, if no other, clutches have not yet been made to compete favorably with rheostats.

Fig. 2 gives a diagram of the car connections for this switch. It will be seen that the current from the trolley wire first goes through the field coils and switch cylinder for commutation, then through the armature and reversing switch, and thence through the switch contact lever and resistance coil (in starting) to ground. It will be noticed that by use of the separate reversing switch the armature wires and field wires are each kept separate and distinct from one another. Formerly there was considerable trouble from the breaking of these wires, especially where the wire entered the brass terminals at the various terminal boards. This has been almost entirely obviated by using 49 strand cable wherever wire was subjected to bending.

In some cases the construction at the platform ends is such as to make it inconvenient to place the rheostat used with this form of switch immediately underneath the cylinder. This is the case when certain kinds of drawbar or step constructions are used. In these cases a modification of the switch arrangements is made that is shown in Fig. 3. Instead of the rheostat a light frame is placed directly under the cylinder. This frame serves to support the switch shaft, upon which is placed a crank connecting with a bar, which is carried off to the rheostat contact lever. With this arrangement the rheostat can be placed under any convenient part of the car flooring and operated as well as when directly under the platform.

Figs. 4, 4A and 4B show general plans of a car switch, designed to be placed under the car and about half way between the motors, when the car construction permits. This design, while open to the criticism that the switch is somewhat inaccessible for inspection, meets the demand that has sometimes being made when it has been thought the space ordinarily occupied by the platform switch could not be sacrificed. The principle is the same as the platform switch already described, but it is modified in form and shape to suit the particular condition under which it is to work, and it is to be noted that the mechanical adjustments required are much more exact, otherwise there would be considerable burning of the contacts, since the motorman would be unable to tell whether or not the switch contacts were on proper positions.

The rheostat is arranged in sections and connections brought from them directly to cylinder contacts. A cylinder is used to commutate both resistance and magnet field coils.

An important point that has been attended to in this switch is the breaking of the circuit on a separate switch instead of on the cylinder. A snap switch, of the knife-blade pattern, is employed to break the circuit at four points. It operates in connection with the cylinder shaft, to which it is connected with a special locking and releasing gear of similar design to that shown in Fig. 1. The first movement of the cylinder shaft closes the snap switch and completes the circuit through the coil. Further movement then disengages the snap switch from the shaft (leaving it closed), and the different commutations are affected. When breaking the circuit the snap switch is again brought into action.

When this form of car controlling switch is used the platform lever is fitted at its lower end with a bevel gear wheel meshing into another gear wheel placed on the cylinder shaft. When necessary an extension shaft, fitted with one or more universal joints, makes connection between the platform lever and the cylinder shaft. When this switch is placed in the middle of the car the amount of car wiring is materially lessened and the car inspection made more easy.

With reference to controlling switches in general, it is evident that a great number of designs may be prepared that will give approximately the same electrical results in point of efficiency. In deciding then upon the merits of a new design of switch, the commercial factor relating to repairs has therefore to be very largely considered, and had designers been able to guide their work more closely from the balance sheets of railroad companies, when such had been properly kept, instead of conforming to popular notions, very much more progress would have been made in this line during the last few years.

In closing this paper it might be well that I should remark that my experience has been largely confined to what is known as the commutated field method of control, and that I have naturally expressed many of the qualities of other methods in terms of this method. If these expressions are not judged satisfactory, I leave it for those who have had a similar experience with other systems to express in their criticisms the qualities of the commutated field system in their own terms.

The Heisler Alternating System for Incandescent Lighting.

Improvements in alternating current apparatus for electric lighting have established its superiority beyond a doubt for long distance house lighting and the illumination of streets and outlying districts in towns and cities where arc lights have not been found desirable. The Heisler Electric Company has recently adapted this type of apparatus also to parallel distribution for short distance installations and isolated plants in a manner that might be considered an improvement on the direct current method, being absolutely safe, exceedingly simple and perfectly self regulating, and owing to the character of the current (alternating), it makes it possible from a practical standpoint for the consumer to either burn his light at full brilliancy or reduce it to any point that may be desirable. This can be accomplished without inserting resistance in series with the lamps, with the consequent waste of energy, which has hitherto been the method adopted. A system which has this range of graduation and adapts itself especially for use in hallways, in the sick chamber and other place where it is not desirable to burn the lights at full candle power, and at the same time results in the saving of the life of the lamps as well as the supply of electric energy, will tend to broaden the sphere of electric lighting.

It is also practicable to operate arc lights from the same circuit and apparatus, which greatly increases the flexibility of the system, as it is frequently found desirable to use a few arc lights in large and open areas such as main halls, rotundas, etc.

The alternating current apparatus as employed for their long distance series system of distribution is provided with perfect automatic regulation, and does not require any special construction or arrangements on the external circuits, or in the station, to provide against the burning out or severe straining of the lights upon the circuit in the event of a lamp at some particular group burning out. Nor are the circuits complicated with transformers in series or other combinations; in fact, nothing further than the automatic regulator and standard ammeter is required to secure the proper balance upon the circuits, making it unnecessary to maintain at the station any complication of devices requiring the constant attention of at least one responsible individual. The automatic regulator takes care of these external conditions with as good results as could be secured from compound wound apparatus.

All that is required for the installation of the lamps is the combination automatic cut-out and lamp socket, which is so constructed that the circuit cannot be opened accidentally or intentionally, and in the event of a lamp filament burning out the circuit is automatically closed. The street and indoor fixtures as used for the installation of the lights are designed to hold lamps from 10 c. p. to 150

c. p., and it is possible to use lamps of any candle power at any point in the circuit.

In the long distance system the 32 c. p. light is taken as the unit, for the reason that considerable is saved in the cost of installation as compared with the 16 c. p. lamp, its life is longer and its efficiency higher, and it has been found to be the most popular size.

The Heisler company claims for its system that it is cheap to install, simple and economical to operate, efficient and reliable. It is now in use in central stations and isolated plants throughout the United States, Mexico and Canada, aggregating a capacity of 200,000 32-c. p. lights.

They also have under construction a very complete transformer system that has been very carefully worked out in both mechanical and electrical details, in which many of the weak points and defects of the existing types of transformer apparatus are claimed to have been overcome.

Stage Effects Produced by Electricity.

Brief mention was made in these columns last week of some interesting electrical features at Proctor's Twenty-third Street Theatre, which appear in the new play "Across the Potomac." The accompanying illustrations show the apparatus by which these effects are produced and the *modus operandi*.

The theatre contains about 1,500 incandescent lamps in all, the majority of them being behind the curtain. Current is obtained from the Manhattan Electric Light Company's main, seven converters, four 800 light and three 100 light, reducing the pressure to 100 volts. The lights are all controlled from a switchboard and rheostats on the left-hand corner of the stage. The rheostats are graduated to 25 divisions, which makes it possible to vary the lights by almost imperceptible degrees.

The sunrise occurs in the last act, and the scene is a most impressive one. The place is within the Confederate fortifications, and the time just before daybreak. Three prisoners are to be shot at the moment the sun appears

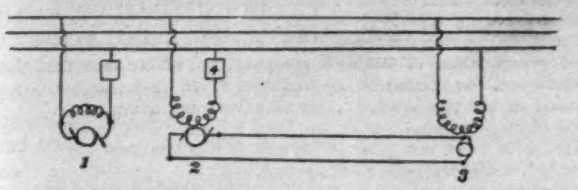


FIG. 2.—LEONARD'S ELEVATOR CONNECTIONS.

above the mountains in the background. Preparations are made for the execution in the dim gray light of the morning, and an officer takes his stand to watch for the first appearance of the rising sun. A faint red tinges the sky, which gradually and imperceptibly deepens until the horizon is all aglow. Just as the day is about to break the officer's attention is attracted by the appearance of a horseman riding furiously down the valley, who, in a few minutes dashes in with a reprieve. Meanwhile the great, red sun has crept up from behind the mountain, gradually lost its color, and finally appears in its own clear, white light. To the spectator the effect is most pleasing and so realistic that he has difficulty in convincing himself that he is in a New York theatre, the witness of an electrical illusion.

Let us go behind the scenes for a moment and see how these effects are produced. A curved scene extends across the whole stage and furnishes the background of mountains. Behind the centre of this scene upon a platform is placed a hand-feed focusing arc light, connected around the 100-volt incandescent mains, which casts a bright round spot, representing the sun, upon the canvas. Suspended over the stage are the ordinary banks of colored incandescent lights, five in all. At convenient places are also placed an ingenious form of bunch light, the invention of the electrician in charge. These lights consist of peculiar shaped reflectors, each containing twelve incandescent lamps, which, by a simple sliding contact, can be turned off or on, one at a time. Gelatine slides passed across the face of the reflectors will produce lights of any desired color, and they have been found very useful, on account of their portability, for touching up scenes here and there.

The electrician first turns on the blue footlights and blue and white lights in the banks overhead, to produce the bluish-gray tint of the early morning. At a signal from him the man in charge of the arc lamp places a red glass before the lens and turns on the current, the light being focused on the back of the mountain out of sight of the audience. A red bank of lights is turned on and resistance gradually thrown out, which deepens the red glow of the rising sun. The bunch lights, with a red gelatine slide, are used to tone up the light, as needed. Meantime an assistant turns the crank, as shown in Fig. 1, which slowly pulls the arc lamp up an inclined plane and gives a similar movement to the spot on the scene. As the sun rises above the mountain the red light is toned down, the red glass gradually withdrawn from the lens, and white lights switched in until when the sun is full up only the brilliant white light is visible. These excellent results have only been produced after long study and practice, and the slightest mishap or misunderstanding of signals is sufficient to mar the whole.

In the second act electricity has again proved itself indispensable to realistic effects where, in the midst of a desperate fight, a bomb is thrown upon the stage and exploded. This is depicted in Fig. 2. A papier-mache bomb made up of separate pieces and stuck together contains just enough powder to scatter the pieces, and produce a flash. In the powder is a fuse wire for about three ampères and wires lead from this to a portable key and thence to the main line. In one of the wings is a small cannon which is exploded by a similar fuse in a circuit that is controlled by the same key. At the proper moment a man throws the bomb out over the stage, and presses the button with his foot. The bomb is apparently blown to atoms, and the spectators, hearing the terrific explosion of the cannon at the same instant, imagine that the innocent shell is the cause of it all.

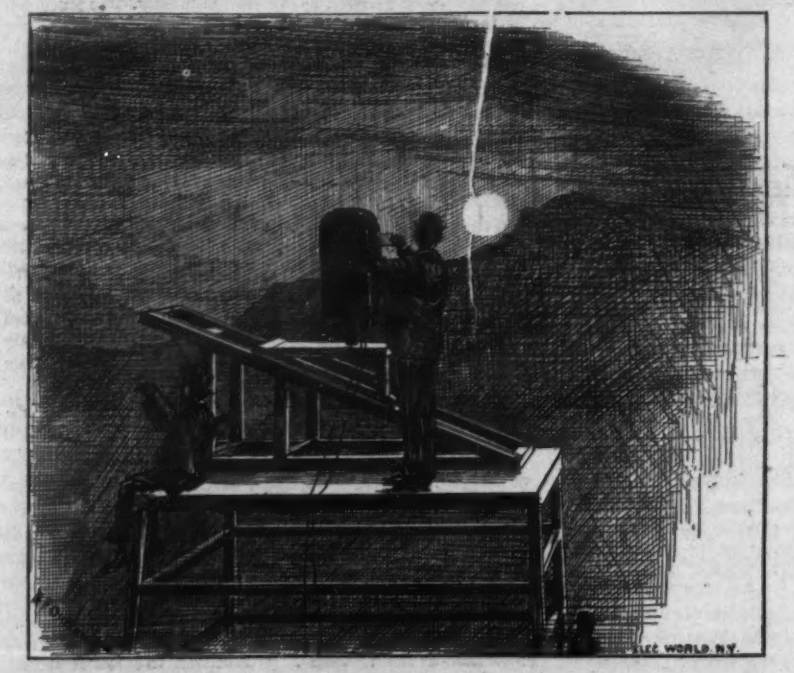


FIG. 1.—AN ELECTRICAL "SUNRISE."

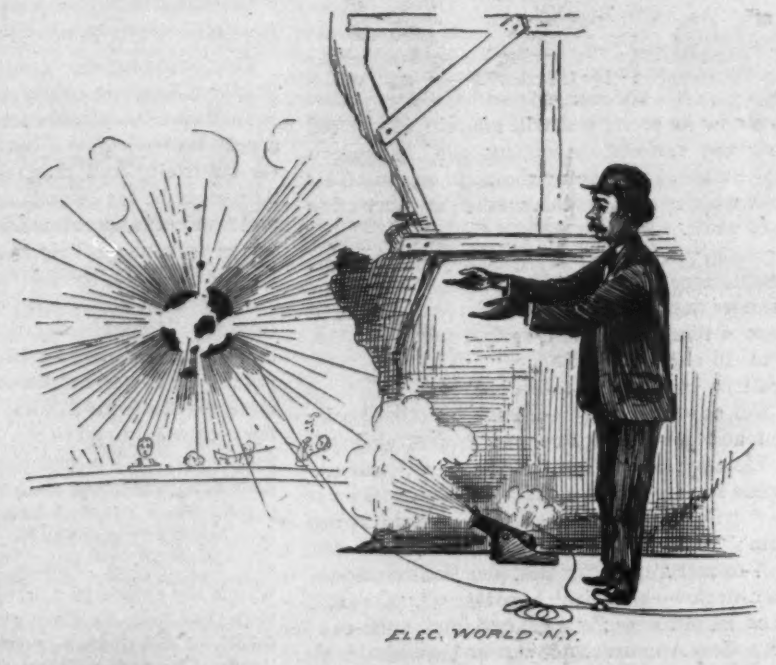
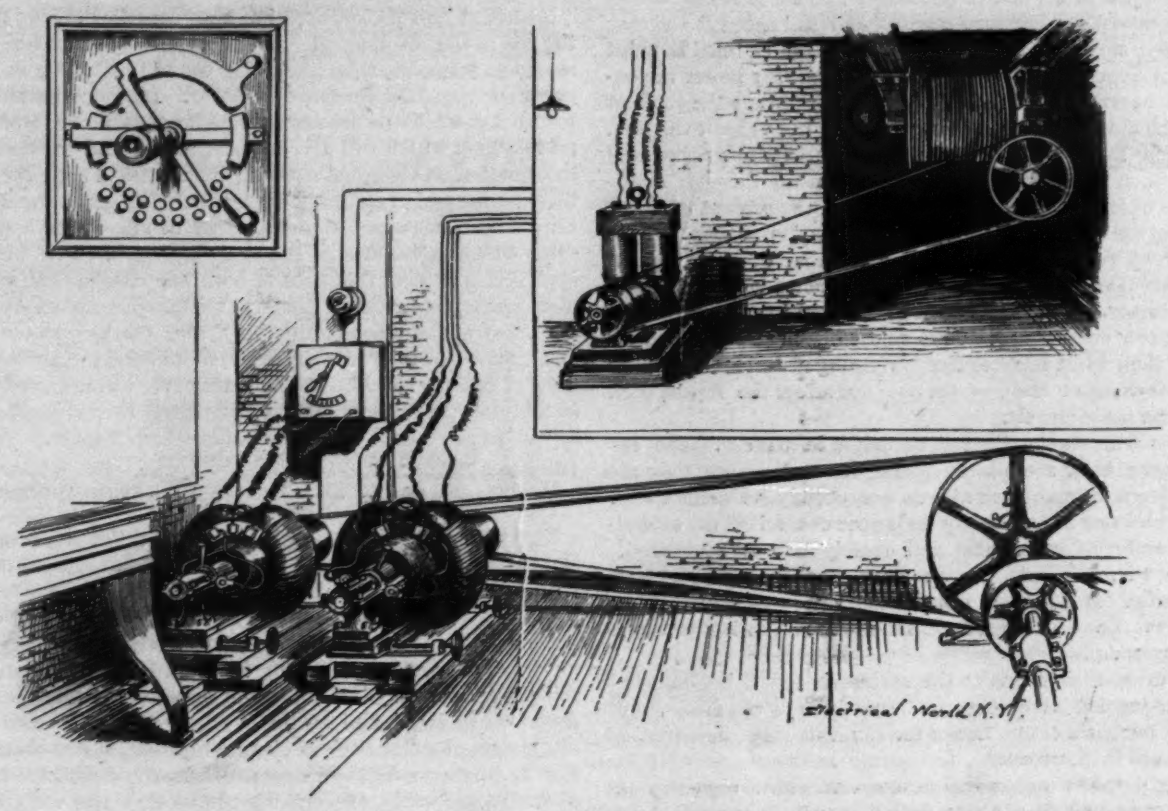


FIG. 2.—A STAGE EXPLOSION EFFECTED BY ELECTRICAL MEANS.

Leonard's Electric Elevator.

The first electric elevator to be installed on the plan suggested by Mr. H. Ward Leonard last year is a passenger elevator in the Edison Pearl street station, Brooklyn. It has operated successfully for more than five months, and can no longer be classed as merely an experiment. Although in constant use, it is stated that on no occasion has it given the slightest trouble, or required any attendance further than that which all electric machinery demands.

The scheme, as is well known, involves the use of three machines, a generator, a motor to drive it, and a separate motor to drive the hoisting mechanism of the elevator. In this plant the generator and its motor, the prime motor it may be called, are situated on the second floor of the station, while the elevator motor is in the basement.



FIGS. 1, 3 AND 4.—GENERAL ARRANGEMENT OF LEONARD'S ELECTRIC ELEVATOR.

The former, which are accurately reproduced in Fig. 1, are both C. & C. machines of similar design and capacity, rated at 10 h. p., and wound for 220 volts. The prime motor is connected as a simple shunt motor across an ordinary Edison three-wire 230-volt house main with a starting rheostat in circuit. It is belted to a pulley on a countershaft, from which the machine shop of the station is run. To the same pulley is belted the generator. Its fields are excited by a circuit from the mains, a loop of which is carried out to the elevator car, and there resistance coils and a controlling switch inserted. The armature of the generator is connected directly to the armature of the elevator motor. The field of this motor is connected across the constant potential mains. The diagrammatic sketch, Fig. 2, clearly shows the connections. 1 is the simple shunt or prime motor, 2 the generator, 3 the elevator motor and 4 the controlling switch in the field circuit of the generator, which is located in the car.

The prime motor, and hence the generator to which it is indirectly belted, runs continuously at a speed which is practically constant at about 1,100 revolutions. The elevator motor is controlled by the reversing switch in the elevator car. When the elevator is at rest the field circuit of the generator is broken; to cause the elevator to rise the circuit is made through a larger resistance, which is

gradually cut out to obtain the desired speed. The generator begins to generate a current at a potential which increases at the same rate that resistance is cut out of the field, and as this current supplies the elevator motor the speed of that motor will increase in the same proportion. At full speed all resistance is cut out of the field of the generator, and to descend the switch is simply thrown over and the current through the field circuit reversed.

A feature of the system is that the speed can be kept fixed at any number of different points, depending only upon the gradation of the controlling rheostat; for if the exciting circuit of the generator is kept constant, the speed of the motor cannot vary; and for any given load the current required is the same for all speeds, so that the efficiency of the system, whatever it may be, remains practically the same, and is not subject to the great variations that take place between starting and full speed in the case where one motor is used. The advantage claimed in point of efficiency is that, whereas in the ordinary motor the energy in watts absorbed from the line is always the product of the ampères used by the motor and the volts of the line, which latter factor remains a constant quantity, and much of the energy is necessarily wasted through resistance at starting and at slow speed, in the present case the energy taken by the elevator motor is the product of the current required and a certain number of volts, which varies directly with the speed, and hence the work done. An important practical advantage resulting from this is that the current required from the line in starting is much less than when the elevator is running at full speed; hence the starting of the elevator does not affect the lights, etc., on the same circuit.

Fig. 3 shows the controlling switch in the car. The resistance coils are placed under the seat, where they are hidden from sight and also do not occupy valuable space. The elevator is completely under the control of the attendant and runs as smoothly and steadily as could be desired.

In Fig. 4 is seen the motor in the basement, with its gearing. It is belted to the ordinary worm gear which revolves the drum around which the hoisting cable is wrapped.

The chief objection to the system is that it is somewhat cumbersome, involving the use of three machines, and thus increasing the first cost. In this case, however, as perhaps in many others, the prime motor was needed for other purposes and only one extra machine required. It was estimated that if shop duty was not demanded of the plant, machines of about half the present capacity would be sufficient.

It is also desirable that the motors and dynamo should be of the same type and design. The Otis Elevator Company is now supplying electric elevators operating under this method and has designed the apparatus so that a motor generator is placed upon the same base as the propelling motor. Several such elevators will soon be in operation in this city and Brooklyn, when a more fair idea of the merits of the system can be obtained than from this crude initial plant which made use without any alterations of the apparatus already employed.

The Brooklyn plant shows that the system is a practical success. Whether the advantages of more perfect regulation will compensate for the additional first cost is a question which experience only can decide. Tests which will accurately define the relation of the efficiency of this system to that now in use will be looked forward to with interest.

NEW BOOKS.

TELEGRAPHIC CONNECTIONS: Embracing Recent Methods in Quadruplex Telegraphy. By Charles Thom and Willis H. Jones.

This work is now in press, and will contain 20 colored plates showing the various connections used in modern telegraphy, the different lines being shown in colors. This is the first book which embodies this method of illustration for this class of work.

ELECTRICAL POWER TRANSMISSION: Principles and Practice. By W. M. Schlesinger and T. C. Martin.

This book is now in press and will soon be issued. It will contain numerous illustrations and tables, and will treat the subject in 16 chapters. The field will be very fully covered, as will be seen by the following titles, which we quote from the advance announcement of the book: "Introduction and Historical Review; Object and Advantages of Electric Power Transmission;" "Considerations as to Prime Movers;" "Principles of Electric Power Transmission;" "Cost and Maintenance of Electric Power Station—Steam;" "Cost and Maintenance of Electric Power Station—Water Power;" "Cost and Maintenance of Electric Power Station—Electrical Apparatus;" "Cost and Maintenance of Power Line;" "Cost and Maintenance of Motors;" "Practical Application of Power Formulæ, with Tables;" "Instructions for Use of Power Formulæ Tables;" "The Selection and Arrangement of Apparatus;" "Examples of Electric Power Transmission—City Central Station;" "Examples of Electric Power Transmission—Mill and Factory Work;" "Examples of Electric Power Transmission—Mining Operations," and "Typical Electric Power Appliances."

A POCKET-BOOK OF ELECTRICAL RULES AND TABLES FOR THE USE OF ELECTRICIANS AND ENGINEERS. By John Munro and Andrew Jamieson. 677 pp. Ills. Price $2.50. Chas. Griffin & Co.: London, 1892.

This is the eighth edition of this well known pocket-book, which has become so familiar to electricians that an extended review of it is unnecessary. Much new matter has been incorporated in this edition to bring the work up to date. It has been entirely rearranged, and a new index compiled for the entire work. Among the new matter in this edition may be mentioned the details of Sir William Thomson's latest form of multicellular and other electrostatic voltmeters, the details of the Siemens current and pressure dynamometers, the Crompton potentiometer testing arrangements, descriptions of the Ferranti meters and cables, a new section on the testing of lamps, electric light and power cables and circuits, etc.

THE MECHANICAL ENGINEER'S POCKET-BOOK OF TABLES, FORMULÆ, RULES AND DATA. By D. K. Clark. 656 pp., 94 ills. Price $3.00. D. Van Nostrand & Co.: New York, 1892.

Although this pocket-book has been compiled chiefly for the use of the mechanical engineer, the large number of electrical formulæ, rules and tables found in it make it of great service to the electrical engineer. Indeed, it has been found that while the mechanical engineer is in need of a pocket-book which will give him condensed and tabulated information on electrical matters, the electrical engineer is likewise in need of a similar book which will give information of this character on mechanical details of the apparatus which he handles in his everyday work. This little book seems to meet this want of both the mechanical and electrical engineer better than any we have heretofore seen, and those who are acquainted with Mr. Clark's elaborate and exhaustive work on the steam engine, and his publications of railway machinery and tramways, will not need to be told that this little book is very complete in its character, as well as accurate in the information which it gives.

DIE AKKUMULATOREN FÜR ELEKTRICITAT. By Edmund Hoppe. 308 pp., 59 ills. Price $3.50. Julius Springer: Berlin, 1892.

This is the second edition of this practical German treatise on the accumulator and its various uses. It has been thoroughly revised and brought up to date, the preface bearing date of February, 1892. The history and theory of the accumulator are especially well treated, and the different types of cell are carefully described and illustrated whenever necessary. A number of accumulator plants are described in detail, and the use of accumulators for different classes of work, such as electric lighting, metal working and telegraphy is very satisfactorily described. A glance at the table of contents shows that the work of American and English inventors has been carefully considered by the author.

HOW TO RUN ENGINES AND BOILERS: Practical Instructions for Young Engineers and Steam Users. By Egbert Pomeroy Watson. 123 pp., 23 ills. Published by the author. New York, 1892.

In this little handbook will be found a great deal of very practical information for the young engineer. The author has endeavored to point out a few of the troubles which are likely to be encountered by beginners, but wisely states that no man can be made an engineer by a book or by rules of any kind, and that experience in steam engineering, as in other branches of engineering, can only be obtained by actual practice. It is necessary, however, for every engineer to know the first principles of his business, and the author has undertaken to put a few of these into a compact and readable form. The book begins by giving practical directions for the cleaning of a boiler, and treats of such subjects as boiler fittings, grate bars or tubes, and the slide valve, the piston, the crank pin, eccentric setting, the making of joints, etc.

BULLETIN OF THE BOSTON PUBLIC LIBRARY FOR APRIL, 1892.

This is the regular quarterly publication of the Boston Public Library in which titles of books added during the preceding three months are given. The current issue is of special interest since it contains an admirable list of works on electricity and magnetism contained in the library. Although the list extends over 24 pages of the publication, and numbers approximately 1,000 titles, it does not include works upon medical electricity, animal magnetism, terrestrial magnetism, the telegraph or the telephone.

The Boston Public Library doubtless contains the finest collection of works on electricity and magnetism to be found in any public library in this country. It often happens that patent attorneys and others desiring to be fully posted on the state of the art in some branch of electrical invention are compelled to go to the Boston Public Library for information. It is a well recognized fact among those who have attempted this class of work in New York City that the facilities afforded here are not to be compared with those of the Boston library. A prominent patent expert in this city, whose name is familiar to all electricians and who is the author of more than one electrical book, recently remarked that he always made a trip to Boston when in search of definite information connected with his work.

The compiler of this list has carefully examined the *Philosophical Transactions* of the Royal Society from volume 71 to the present time, and has entered in the list all articles on electricity that have appeared in these volumes. A large number of works are to be found in the collection that are of special interest as bearing upon the history of electrical invention in America. Among these may be mentioned the pamphlet of Thomas Davenport on "Electromagnetism," published in 1837; a "Brief Essay of Electromagnetism, with a Full Description of Models of Davenport's Machines," by C. Griglietta, published in Philadelphia in 1838; and the works of Henry, Ritchie, Franklin and others. One is somewhat surprised, however, to find that the library does not contain Prof. C. G. Page's "History of Induction," a work published at Washington in 1867. In this respect, however, the library is not alone, since Dr. J. A. Fleming in his articles on the induction coil recently published in the London *Electrician* states that he was unable to find a copy of this work in either the British Museum or the library of the British Patent Office. The compiler of this catalogue has done an admirable piece of work, as it is remarkably free from errors. One cannot avoid the impression that it must have been done by a cataloguer who was especially familiar with electrical authors and their various works.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

NEW YORK, April 23, 1892.

The market this week has fulfilled our predictions, that the bull elements were on top and an active and better market was imminent. Following the recent holidays in the Exchanges there has been a better feeling on all sides. Though no particular boom has resulted, still we note higher prices on most of the securities and a kind of spring rejuvenating in place of the lethargy that has tightly held the market within the narrow bounds of professional trading during the months of the first quarter of the year. Together with these improving conditions in the stocks, the money market has been even duller than ever. Call loans have been made as low as two per cent.; but these were few, as there has been little or no use for the money. Money with the banks is a drug at one and a half per cent. Commercial paper is scarce but active at three and a half to five per cent. Though the prices on stocks are generally higher by one or two points than last week, there is not yet sufficient activity to bring the volume of business up to the usual standard of a lively market. Strength is not always a synonym for activity in stock parlance, and so it is at present, while the bulk of business is light.

The electric stocks have figured principally in this week's business and have each one scored a large advance. The brokers' favorable opinion of these stocks and the present good condition of the companies' internal affairs combine in making a bull market on the electrics all round. The two consolidated companies' stocks are advancing together, beyond the price of the combination. Thomson-Houston has reached 62⅝ and Edison 104½. The successful incorporation of the new company, and under most favorable terms too, has tended to inspire even more than the usual confidence in the two stocks. And also the fine showing of the Thomson-Houston annual report has been a strong card for the stock. The sales have not been large, and in fact less than would be expected, considering the rise in prices.

Westinghouse Stock.—Active and substantial buying has put Westinghouse up still higher than it has been at any former date. The preferred stock has furnished a majority of the sales. As is natural, this seems to be considered even more favorably than the common. Its dividends are looked upon as assured, not only from the good business that the company is now doing, but from the prominence of this stock's claim upon the earnings. Authoritative reports are that the common stock will have a dividend this year, as the increase of business would seem to make this possible. The common stock has reached 31¼ and the preferred 48. Its supporters are still figuring on a place for this company in the consolidation.

Western Union continues to make a new record each day, and increases the lead on old prices at a rapid rate. Apparently authoritative reports state that the regular dividends will be increased to six per cent. Other favorable changes are anticipated for the benefit of stockholders, which naturally tend to increase the confidence in this stock. The outsiders look for it to go above par and even refuse to make bets on this point. It reached 93¾, thus far the highest figure.

Bell Telephone stock has also steadily advanced to maximum figures. This is due to certain acquisitions of patents, which have recently been assured. The ones in question now are the patents of Edison on the carbon contact, which will be issued May 3, and have been secured by the Bell Company. The stock has reached 208½, and the rights have sold as high as 16⅜. These two taken together bring the price up to one of the highest figures that it has reached for many months past. This is natural perhaps in view of the recent annual report of the general favorable condition of the company's affairs.

The North American Company.—Some parties in Philadelphia are apparently bringing to light again the affairs of the North American Company and were recently large purchasers of the stock. It is supposed that this company has in view the control of the street car system in the principal cities of the country. The company now has control of many of the most valuable patents for electric traction, and it may be that through these it will be able to offer sufficiently attractive inducements to gain the control that it is now apparently working for.

West End Street Railway Stock.—It is stated that the proposed issue of 40,000 shares of West End Street Railway stock is underwritten at 71⅝ and that it will net the company $70 per share, or $2,800,000—a premium of $800,000. The sale by auction of the 40,000 shares of new stock will begin May 2, and 2,000 shares will be sold each day until the entire amount is disposed of. The net earnings of the company for six months ending April 30 made a gain of $163,000. The gross earnings of the road continue the average increase of about $1,000 per day.

Annual Reports.—The annual report of the Mexican Telephone Company, made at the annual meeting of the company, April 20, shows net earnings of $29,697, an increase of $8,887; telephones in use, 1,241, an increase of 118. It was decided to purchase the Mexican Northern and Central Telephone companies, and to guarantee its $20,000 six per cent. 20-year bonds. Of this amount one-half is now held in the treasury. In addition to this a sufficient amount of treasury stock was authorized to be issued to retire the stock of the Northern and Central on the basis of one share for twenty. The annual return of the Hull (Mass.) Electric Light and Power Company shows its capital to be $10,000. Directors: Henry F. Holland, president; Z. T. Harrington, treasurer, and G. A. Beatey.

Increase in Capital Stock.—The Bell Telephone Company's bill empowering it to increase its capital stock from $500,000 to $5,000,000 has been approved and favorably reported by the banking and commerce committee of the Canadian House of Commons. A special meeting of the stockholders of the United Electric Light and Power Company will be held at the office of the company, at the Times Building, No. 41 Park Row, New York, on Tuesday, May 3, at 11 o'clock in the forenoon, to determine whether the capital stock of said company shall be increased to the amount of $5,000,000 par value, the increase to consist of 25,000 shares

of the par value of $100 each, so that the entire capital stock shall consist of 55,000 shares of the par value of $100 each. In case the stockholders at said meeting shall authorize the increase of the capital stock to five million five hundred thousand dollars ($5,500,000) they will be asked to determine at the same meeting whether two million dollars ($2,000,000) par value of the two million five hundred thousand dollars ($2,500,000) par value of new stock so authorized shall be made preferred stock entitled to a cumulative preference of six (6) per cent. per annum out of the first earnings of the company before any dividends are paid on the common stock, or whether said increase of stock shall be common stock or stock preferred in some other amount or in some other manner than stated above. A call has been issued for a meeting of the stockholders of the Chicago Edison Company to decide the question of increasing the capital stock from $1,000,000 to $3,000,000. The capital stock of the Plymouth (Mass.) and Kingston Street Railway Company has been increased to $70,000. A bill granting the Edison Electric Illuminating Company, of Boston, the right to increase its capital was passed in the Massachusetts Legislature April 22.

Dividends.—The Dover, N. J., Electric Light Company has declared a dividend of 3 per cent. and will pay semi-annual dividends hereafter in proportion to the company's earnings. The Asbury Park, N. J., Electric Light and Power Company has declared a semi-annual dividend of 3 per cent. The Bell Telephone Company of Canada has declared a dividend of 2 per cent. The Plymouth, Mass., and Kingston Street Railway Company has paid dividends of $6 per share on last year's business.

Closing Quotations.—The following were the closing quotations of electric stocks on Saturday, April 23, 1892, in New York and Boston:

NEW YORK QUOTATIONS.

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
American Telegraph Co.	100	14,000,000	60	63
Western Union Telegraph Co.	100	80,200,000	92	92⅛
Commercial Cable Co.	100	7,716,000	155	160
Edison General Electric	100	15,000,000	101	102
Edison Illuminating Co., of New York	100	4,500,000	81½	82½
" " " Brooklyn	100	750,000	76	80
" " " Chicago	100	750,000	138	142
U. S. Illuminating Co.	100	1,250,000	30	35
Edison Elec. Light Co. (of Europe) stock	100	2,000,000	2½	5
Edison Elec. Light Co. (of Europe) bonds	sh	30,000	65	75½
" Ore Milling Co	100	2,000,000	15	20
" Toy Phonograph Mfg. Co	10	1,000,000	....	⅛
Brush Illuminating Co., of New York	50	1,000,000	40	50
Mt. Morris Electric Light Co.		500,000	20	40
East River Electric Light Co.	100	1,000,000	...	60
North American Phonograph Co.	...	6,800,000	5	8
New York Phonograph Co.	...	2,000,000	3	4
Automatic Exhibition Co.	...	2,000,000	3	6
New England Phonograph Co.	...	2,000,000	1¾	2¾

BOSTON QUOTATIONS.

	Par.	Capitalization.	Highest.	Lowest.	Bid.	Ask'd
Thomson-Houston Elec	25	6,000,000	62⅝	59¾	61⅛	62
Thomson Houston Elec. preferred	25	4,000,000	29	25⅛	28¾	29
Thomson-Houston Elec.—Series C	sh	40,000	....	....	8¾	9
Thomson-Houston Elec.—Series D	sh	120,000	7⅛	....	7⅝	7⅛
Thomson-Houston Int'n'al Elec.	100	600,000	....	....	200	225
Thomson-Houston Int'n'al Elec—Pfd	100	400,000	....	....	102	103
Thomson Elec. Weld.	100	1,000,000	....	....	55	60
Thomson European Elec. Weld	100	1,500,000	....	....	10	12
Westinghouse Elec.—New Com.	..	6,000,000	30¾	28	30	30½
Westinghouse Elec.—Pfd.	..	4,000,000	48	42½	47	47½
" " " Trust receipts	..	10,000,000	....	....	....	....
Fort Wayne Elec.	25	4,000,000	13	12½	13¼	13½
Fort Wayne Elec.—Ser. A.	sh	80,000	7½	7¼	7¼	7½
Detroit Elec	10	1,000,000	7½	....	7	7½
West End St. Ry. Co.—Com	50	7,150,000	72¾	72	72½	73
West End St. Ry. Co.—Pfd	50	6,400,000	86½	....	86½	....
American Bell Tel	100	15,000,000*	208	199¾	201½	205½
Erie Tel. & Tel. Co.	..	4,800,000	46¼	46	46	....
Mexican Tel. Co.	10	1,280,000	1.05	....	1.00	1.10
New Eng. Tel. & Tel. Co.	..	10,304,600	53	....	52½	53
Tropical Tel. Co.	10	400,000	40c.	...	40c.	....

* Ex rights, 16.

NEW INCORPORATIONS.

The Muncie Electric Street Railway Company, of Muncie, Ind., capital stock $100,000, has been formed to operate an electric line of street railway in Muncie, etc. David Camack, Wm. L. Little, Darius C. Mitchell, Roscoe C. Griffith and John M. Kirby are the promoters.

The Silver Bow Electric Light and Power Company, of Butte, Mont., capital stock $200,000, has been started to carry on a general electric lighting, heating and manufacturing business, etc. The incorporators are W. F. Bartlett, Jas. W. Forbes and J. R. Wharton, of Butte.

The Electrical Protection Company, of Jersey City, N. J., capital stock $100,000, has been formed to manufacture and supply the apparatus necessary for equipping houses, etc. H. W. Spang, N. B. Amory, New York City, W. Bruns, J. N. Bruns and P. Sury, Jersey City, N. J., are the promoters.

The Pasco Union Land Company, of Pasco, Wash., capital stock $750,000, has been incorporated for the purpose of dealing in and improving real estate, and to construct and maintain street cars, lines, electric light plants, etc. Louis C. Frey, R. Olney and W. P. Gray, of Pasco, are the organizers.

The Electric Power and Transmission Company, of Baker City, Ore., capital stock $150,000, has been incorporated to generate electricity for any and all purposes. B. W. Levens, E. L. Giroux, Wm. H. Packwood, Jr., of Baker City, Ore., and Geo. Amslie, of Boise City, Idaho, are the organizers.

The Hamburg Electric Light and Power Company, of Hamburg, Pa., capital stock $15,000, has been started to supply light, heat and power by electricity to the borough of Hamburg, etc. The promoters are Milton L. Ritter, of Windsor Castle, Pa.; G. F. McHarg and F. S. Correll, both of Hamburg.

The Columbian Electric Company, of Camden, N. J., capital stock $200,000, has been formed to manufacture, sell and lease electric lights and electricity for heating and power purposes. Those interested are S. J. MacFarren, Pittsburgh, Pa.; F. H. Elder, Philadelphia, Pa., and T. P. Curley, of Camden, N. J.

The Catasauqua and Northern Street Railway Company, of Catasauqua, Pa., capital stock $50,000, has been formed to operate an electric railway from that town to and through the villages of Stemton and White Hill. G. H. Campbell, Geo. W. Mansfield, of Boston, Mass., and R. E. Wright, of Allentown, Pa., are the organizers.

AFFAIRS OF THE COMPANIES.

The United States Telegraph Company will hold its annual meeting in New York on Monday, May 2, at 12 o'clock noon, for the election of directors, etc.

The Manhattan Electric Light Company, of New York, will hold its annual meeting on May 11, at 12 o'clock noon, for the purpose of electing a board of directors, etc.

Judgments have been entered aggregating, it is stated, $40,000 against Allen & Swiney, proprietors of the Electric Railway in Dubuque, Ia., in favor of Eastern creditors.

The Millville-Schuyler Electric Light Plant at Millville, N. J., was sold at sheriff's sale recently to Wm. Corbin, of Jersey City, for $1,525. The plant originally cost about $12,000.

Sale of an Electric Plant.—The plant of the Keokuk, Ia., Electric Street and Railway Power Company has been sold at commissioners' sale to S. P. Townsend, of Hartford, Conn., for $21,000.

The National Electric Light and Power Company, of Philadelphia, on petition of Edwin A. Morgan, Jr., has been placed in the hands of Elias P. Smithers receiver, and an injunction has been issued restraining the sheriff from selling its property.

The Mexican Telephone Company held its annual meeting in New York on April 20, and the following directors were elected: Robert Colgate, W. A. Paine, W. French Smith, Robert Bacon, James H. Davis, Orlando P. Dexter and John D. Sargent. It was decided to purchase the Northern Central Telephone Company.

The Brush Electric Illuminating Company, of New York, held its annual meeting recently and re-elected the old board of directors. The following officers were elected: W. L. Pomeroy was elected president and G. McFall secretary and treasurer. The annual financial statement of the company will be made on May 25.

The Dover Electric Light Company, of Dover, N. J., at its recent annual meeting voted to reduce the number of directors from nine to seven, and the following were elected: D. S. Allen, Chas. E. Clark, John H. Pierson, A. Kanouse, I. W. Searing, George McCracken and James H. Neighbour. The board has elected D. S. Allen president, I. W. Searing secretary, and J. H. Pierson treasurer. The annual report showed that the company was on a dividend-paying basis, and a dividend was declared, as noted elsewhere in this issue.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, April 25, 1892.

Prof. Elisha Gray, of Highland Park, Chicago, sailed for Europe to-day.

The Northern New York Telephone Company will hold its annual meeting in this city on Wednesday of this week at 11 o'clock A. M., for the election of officers, etc.

Irving Loveridge, purchasing agent of the Western Electric Company, of this city, sailed for Europe Saturday to take charge of the Western Electric Company's factory at Antwerp.

Mr. G. Waldron Blake has been appointed New York agent of the Mather Electric Company and of the Perkins Lamp Company, and has opened offices at room 114 Bennett Building.

W. H. Mason, general manager of the Railway Equipment Company, of Chicago, made us a pleasant call Saturday last. The outlook for business with his new company is of the brightest. Several large contracts have already been secured.

Mr. B. F. Leavitt, general manager of the Porter Leavitt Motor Company, of Providence, R. I., called at our office on Friday of last week. His company is very busy at the present time on motors Nos. 1, 2 and 3, and will soon bring out a new motor wound for 110 volts.

It has been reported that Mr. J. P. Barrett, chief of the department of electricity of the World's Fair and city electrician of Chicago, has received from the National Board of Underwriters of New York an offer of $25,000 a year to come to New York and take charge of their department of inspection on electric risks. The National Board deny that there is the slightest foundation for such a rumor.

Col. W. H. Eckert, who has been identified with the telephone and telegraph business for a number of years, and who of late has represented Day's Kerite wires in the capacity of general agent, will on May 1 accept the general superintendency of the Gray National Telautograph Company, with offices at 80 Broadway, this city. The company, we understand, has ample capital behind it, and with Mr. Eckert at the helm there is no doubt of its success.

Mr. Franklin L. Pope has accepted the position of electrical editor of the *Engineering Magazine*, published in this city. This journal has been before the public but little over a year, yet it has been remarkably successful. It is well conducted and well edited, and Mr. Pope's connection with it will be a guarantee that the important subject of electricity will receive the care and attention it deserves.

Hotel Telephones.—The new Hotel Waldorf, in New York, it is stated, is to be fitted with telephone communication between the office and every room in the house. This is a system in use abroad, notably in the Adelphi, Liverpool. This feature in hotel service is an important one, especially in the saving of time. Instead of pushing the button and waiting for the bell boy to answer the ring, guests can communicate their order to the office at once and have it filled in one-half of the time.

A Correction.—In our last issue it was stated that Mr. C. H. W. Copeland, of 136 Liberty street, was the general agent of The Mica Asbetite Insulating Company, of 444 Pearl street, New York, manufacturer of Kimble's Electric Railroad appliances. Most of our readers would recognize this as an erroneous statement, as Mr. Copeland gives his entire time to the engine business. The agent of the above company is Mr. J. A. Cross, whose office is in the Electrical Exchange Building.

New Electrical Subways.—The Board of Electrical Control at its meeting to-day selected about fifty streets in which subways are to be built subject to the approval of the engineer of the board. A resolution was adopted to refuse permits to subway contractors to tear up streets which have been repaved by the present Commissioner of Public Works. On such streets the Subway company must lay its ducts under the sidewalks. The total length of the additional subways ordered is seven and one-half miles.

The United States Electric Light Company Appeals.—In the Court of Appeals of the Circuit Court for the Southern district of New York, this morning, the case of the Edison Electric Light Company against the United States Electric Light Company was opened, on the appeal of the latter from the decision of the Circuit Court granting a perpetual injunction and awarding damages to the Edison company for the use of incandescent lamps by the United States company. This is the first case before this court, which was recently created, and is the only case on its calendar, and will probably continue for a week.

The New York Telegraph Club gave a dramatic entertainment and reception on Friday evening, April 22, at the Lexington Avenue Opera House. President E. E. Brannin in a most appropriate address presented Mrs. E. C. Cockey and Mrs. W. J. Dealey elegantly framed pictures of their respective husbands, a gift from the club. The dramatic entertainment which followed the reception was one of unusual merit, and the reception, although not as large as it would have been had the weather been more auspicious, was such a pleasant affair that it will long be remembered by those fortunate enough to have attended.

The Electric Club.—The annual election of officers was held on Thursday evening, April 21, at the club rooms, No. 19 East Twenty-second street. The following revised regular ticket was unanimously elected: President, Samuel Insull; vice-presidents, Edward Weston, E. A. Leslie, W. L. Candee, H. J. Smith; secretary, Stephen L. Coles; treasurer, Geo. M. Phelps; board of managers, Chas. D. Shain, Joseph Barre, James Kempster, H. D. Cheever, T. C. Martin, John A. Seely, R. B. Corey, W. J. Morrison, E. F. Peck, Dr. J. B. De Lery, E. E. Bartlett, Frank R. Chinnock; committee on membership, Chas. Dulton, C. E. Stump, Geo. T. Manson, Jos. Wetzler, C. O. Baker, Jr. It was also decided that the club would continue to occupy its present quarters for the ensuing year.

The New York Electrical Society was given an opportunity on the evening of April 21 to explore the mysteries of the Central Exchange of the Metropolitan Telegraph and Telephone Company, 18 Cortlandt street. The party was conducted over the building by Mr. J. J. Carty, who gave a brief but clear explanation of the various apparatus, and courteously answered any question asked. An opportunity was given those present to listen to a conversation with the chief operator at Boston, 40 receivers being connected in parallel. The long-distance operating room, the operators' quarters, the storage battery plant, the disposition of the cables as they come in from the subways, were points which attracted the attention of all. The interest centred, however, in the great switchboard on the top floor, the largest one in the world. Few persons realize the difficulties and the expense of installing and maintaining such a complex system as that of the Metropolitan Company. The switchboard alone cost $350,000, leaving out of consideration the cables, labor, etc. A separate operator is required for every nine subscribers. One of the discouraging things in this line of work is that every few years the apparatus becomes antiquated and has to be replaced by new. Mr. Carty thought that the present switchboard would not be in existence five years hence. L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, Mass., April 23, 1892.

The Detroit Electrical Works' New England office has been removed to room 23 Fiske Building, 89 State street.

Mr. Charles M. Jarvis, president of the Berlin Iron Bridge Company of East Berlin, Conn., has been appointed chairman of the World's Fair Building Committee of the State of Connecticut by Governor Bulkeley.

Mr. Frank H. Monks has resigned as the general manager of the West End Street Railway Company, and President Whitney will temporarily take charge of that office. Auditor Sergeant is mentioned as his possible successor.

Equipment for Lynn & Boston Railroad.—Considerable of the equipment for the Lynn & Boston Railroad Company will have to be supplied early this summer, as the work of construction for the change from horses to electricity is being rapidly pushed. The new power station in Lynn will be soon completed, as the roof is already in position, and the slaters will be at work on it this week. The Lynn & Boston Company will also commence work building the power station at the Chelsea end of the line this week.

Mechanics' Hall to Be Lighted by Electricity.—Mechanics' Hall is to be lighted by electricity from its own plant, which is to be set up in time for the next exhibition. This was decided at the recent quarterly meeting. The estimate provides for lighting the entire building, and contemplates the use of 150 arc and 2,000 incandescent lamps, obviating the necessity of using any gas burners. At present the building is lighted by 106 arc, 1,216 incandescent lamps and 1,863 gas burners.

Electric Locomotives.—The electric locomotive which is being built in factory L. at the Thomson-Houston Electric Company's works, at Lynn, is rapidly approaching completion. It will be a monster in its way, of some 500 h. p., and destined to take the place of a steam engine on a railroad for pulling either passenger or baggage cars. The electric locomotive is sure to grow, the tendency being very much in this direction, as a prominent official of the Northern Pacific Railroad Company said not long ago that this road would be run by electricity inside of three years. If so it is probable that the locomotives will be furnished by the Thomson-Houston Company.

The Thomson-Houston Electric Company, it is stated, has transferred the work on the 400-h. p. generators which it has been building to the Edison works at Schenectady. One of these generators was completed about the time the consolidation was consummated, and then it was decided, because of the better facilities at Schenectady, to transfer the work to that place. This is the only change which has been made in the manufacturing department thus far as a result of the consolidation plan. The next transfer, as a result of the consolidation, it is stated, will probably be the bringing of the arc light work from Schenectady to Lynn and ultimately transferring the incandescent work to Harrison, N. J. The work being done at Schenectady is under the direction of the Lynn management, daily communication with the Schenectady shops being had by means of the long distance telephone. The company at present is constructing a large amount of apparatus for lighting the World's Fair grounds at Chicago. This order is very large, as the first contract is for 3,500 arc lamps, also a large number of arc dynamos. These lamps and dynamos will, it is stated, be supplied from the Chicago office of the Thomson-Houston Company, but they will be constructed at the Lynn factories. W.R.W.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, April 23, 1892.

Mr. A. D. Adams, the traveling sales agent of the Jenney Electric Motor Company, of Indianapolis, Ind., was in Chicago on Wednesday closing some special motor contracts.

General Manager Wheeler, of the Eclipse Clutch Works, of Beloit, Wis., has recently secured additional handsome and extensive contracts for power transmission machinery.

The Star Electric Company, of Des Moines, Iowa, has been organized to do a supply and construction business with a capital stock of $3,000. Mr. F. M. Pierce, formerly with the Chicago office of Gleason & Baily, will manage the new company.

Mr. P. C. Burns, the general manager of the Peru Glass and Carbon Company, of Peru, Ind., is calling on the trade in the West. Mr. Burns has recently completed an extensive addition to his factory, an event that was duly celebrated by an attractive ball and banquet.

Mr. C. A. Rusling, of the railway department of the Thomson-Houston Electric Company, was a welcome visitor in Chicago

on Saturday, stopping over en route to New York. His many friends will be more than sorry to learn of the death of Mrs Rusling at the residence of Mr. Rusling's father, at Lawrenceville, Pa.

Mr. A. D. Colton, formerly with the Racine-Hardware Manufacturing Company, is now connected with the M. C. Bullock Manufacturing Company, and will have charge of their new warerooms, corner of Washington and Canal streets, Chicago. The representatives of the allied industries are to be congratulated on securing so valuable an addition to their membership.

Sold to the Highest Bidder.—The plant of the insolvent Belding Motor and Manufacturing Company, at Hermosa, has been sold by the county court to the highest bidder for $71,800. T. J. Indermille, formerly with the Belding company, was the purchaser. His title is subject to a $40,000 mortgage. The company was engaged in the manufacture of electric motors for street cars, but, owing to a series of fires in the factory, was forced into insolvency. The assignment was made last May, leaving an estate worth $100,000 to be divided among creditors.

A Novel Lighting Plant.—From a Mayo-Rockford incandescent dynamo suspended above a 6-h. p. Payne vertical engine, current is supplied to 65 lamps distributed within and around the railway car known as the "Placer county on wheels," a traveling combination intended primarily to advertise the prolific fruit region of northern California. The furnace, boiler, engine and dynamo are placed completely in one corner of the car, and so satisfactory has been the service obtained that Mr. Leak, the owner, is now figuring with the Rockford Electric Manufacturing Company for the equipment of an entire train.

The Chicago Edison Company has purchased a site for its proposed new plant for $190,000. The property consists of the south end of the irregular shaped block bounded by Van Buren street on the north, the Chicago River on the east, Charles street on the west, and Harrison street on the south. On this land a building will be erected involving an outlay equal to that represented by the purchase of the land. It will be two or three stories in height and the plant, fully equipped, will cost $500,000. Sub-stations will be established on the south and west sides, which will not be so extensive as the one located on the Chicago River, to supply the down-town district.

Chicago Electric Club.—The annual meeting and election of officers was held in the club rooms. Thursday, April 21, the polls being open only from 4 to 6 P. M., and the following named officers were elected: President, B. E. Sunny; First Vice President, F. B. Badt; Second Vice-President, Alex. Kempt; Third Vice-President, M. A. Knapp; Fourth Vice President, W. B. Pearson; Secretary, W. A. Kreidler; Treasurer, F. A. Terry. Managers: F. W. Parker, Chairman, Geo. C. Bailey, E. Baggott, J. P. Barrett, W. J. Buckley, F. W. Cushing, F. E. Degenhardt, E. R. Gilman, J. J. Nate, C. H. Wilmerding. Membership Committee: C. C. Haskins, Chairman, T. G. Grier, Geo. Cutter. Early in May the club will move to its new quarters corner of Clark and Monroe streets.

Mr. George Westinghouse, Jr., has been granted a hearing by Chairman Higginbotham, of the Committee of Ways and Means, and Vice-Chairman W. P. Ketcham, of the Committee on Grounds and Buildings, in view of the complaint of Mr. Westinghouse that he was not treated fairly when the Committee on Grounds and Buildings let recently the contract to the Edison General Electric Company for furnishing the 92,000 incandescent electric lights needed at Jackson Park. The bid of the Edison company was $5.95 a light. Mr. Westinghouse, after all the first bids had been rejected, says he handed in a written proposal for the work at something over $3 a light and it is stated he may apply for an injunction against the Exposition company for awarding the contract as it did. The Electrical Construction Company, which was one of the original bidders, has addressed an open letter to Vice-President Higginbotham on the same subject.

To Test a New Electric System.—The Intramural Transportation Company was incorporated recently in Illinois with a capital stock of $1,000,000. The company is formed for the purpose of developing a new underground conduit system for an electric railway. The inventor, J. B. Odell, claims to have discovered a system which will do away with many of the chief difficulties previously encountered. The wire is to be protected by an insulating piece of wood covered with a brass rod, connection being established underneath so as to effectually prevent the presence of moisture and other disturbing elements, as its promotors claim. If the new system proves to be all that is urged for it upon a practical test, a solution is offered of the rapid transit question in crowded metropolitan districts. The incorporators of the company are Stephen D. May, Orlando Briggs and James O. Martin.

The Love Electric Traction Company has closed negotiations with the North Chicago Street Railroad Company, by which the former company takes possession of the Love company's loop, running around the circuit bounded by Fullerton, Racine and Webster avenues and Halsted street. The transfer, it is stated, is really in the nature of an exhaustive test to be made by the Yerkes company. General Manager Wheeler, of the Love company, in a recent interview stated, "I cannot state all the details of the transaction, but our company has looked after its interests, and this transfer means that if the road stands the test to be made by Superintendent Roche, of the North Chicago company, the North Side company will put the Love system in on its lines which are not cabled. We are not afraid of the result. Every conceivable test has been made by us, and we believe there is not a defect left. We can afford to give the North Side company the road we have built for nothing if it will adopt the system, because that will mean its indorsement."

A Handsome Catalogue.—Typical of the healthy condition of the progressive branch of that great modern industry that has astonished the world with its rapid growth is the large octave volume resting on my desk and bearing the imprint of the Electrical Supply Company, Chicago. For between the dark brown, attractive covers, on which golden lettering and dainty design give fair idea of the treat within, are 500 pages of carefully selected and handsomely illustrated matter that will be read many times over by the electrical fraternity. The type is clear faced, the illustrations which are fresh and bright, and suggestive of advanced thought and independent work along the most approved lines in electrical engineering, are made doubly interesting by the high grade of book paper used, while the substantial binding will cause this work to be sought for and treasured as a complete compendium of all that is latest and best in the line of supplies for electric light, railway, power and mining installations. The contents are divided under ten heads, and, to facilitate quickly finding whatever is desired, there is an alphabetical index covering nine pages, an index of trade numbers covering six pages; and an index to the tables, formulæ and general information so generously furnished for the use of electricians and those engaged in electrical work. Thirty pages have been devoted to the subject of insulated wires, cables and cord, equipment material and special line devices; station equipment material, and house equipment material have 35 pages each; tools and construction material, 65 pages; manufacturers' special material, 24 pages; electrical testing instruments, 26 pages; while 30 pages are devoted to miscellaneous subjects. Then there are 30 pages "devoted to tables and formulæ, originally compiled by high electrical authorities, and now presented with such modifications as are suggested by the latest knowledge and investigation." This valuable work, in the production of which so many weeks of continuous exhaustive labor is represented, will be classed as a catalogue, though it is more than that. But as a catalogue it is the most thorough and complete one of its kind ever sent out, and he who studies well the information contained will reap the benefit in economic purchases of that which time, experience and varying conditions have proven most satisfactory.

F. DE L.

Inquiries from Correspondents.

Queries to be inserted in this column must be of general electrical interest, and must be accompanied by the real name and address, not necessarily for publication, but as a guarantee of good faith. No notice will be taken of questions which involve nothing more than can be found in elementary treatises on the subject. All correspondence should be as brief as is consistent with clearness. Readers are invited to send discussions and answers to these questions, which will be inserted in the column below.

[86.] Does the north magnetic pole of the earth correspond to the north pole of a magnet? H. E. C.

[87.] What is the general composition of a dry battery?
E. D. F.

[88.] Is it considered practicable to run six 50-volt arc lamps and two 16-c. p. 100-volt incandescent on a 500 volt street railway circuit? E. M. R.

[89.] In what does the long-distance telephone instrument differ from the ordinary Bell district telephone, and what are the respective resistances of the "secondaries" of the induction coil of the two instruments? J. B.

[90.] How can the voltage of a given source of electricity be ascertained without the aid of the expensive measuring instruments, which are generally beyond the reach of amateurs? J. B

[91.] Can one or more cells of a storage battery be charged from an incandescent 112 volt circuit by connecting the negative wire of such circuit to the cells, and thence to the ground (with proper resistance inserted), without interference with the lights? J. B.

[92.] With water power twelve miles from the centre of a ten mile electric railway system would I get satisfactory results from a direct current of 600 volts at dynamo? T. A. W.

[93.] What is the formula for the solution used in a medical battery? W. C. H.

[94.] At what temperature does nickel become non-magnetic?
F. S.

[95.] How many watts represent 1,000-c. p. on an arc circuit?
R. W. G.

[96.] Should one figure differently in finding the candle power by watts on direct and alternating current circuits? R. W. G.

[97.] What is the highest candle power arc lamp known to be burning successfully at the present time? R. W. G.

[98.] Is there sufficient leakage from the flexible cords wound round gas fixtures to make any difference in the reading of an Edison meter? C. A. F.

[99.] How can a selenium cell be constructed, and where can the materials be obtained? H. C. B.

[100.] What experiments have thus far been made with selenium cells susceptible to the influence of light, and where can a description be found? H. C. B.

Answers to Correspondents.

Readers are invited to send discussions regarding, or answers to, the queries published in the column above, or with regard to any other live questions on electrical subjects. In answering questions please refer to them by their serial number. Correspondence must be accompanied by the real name and address, not necessarily for publication, but as a guarantee of good faith. Names of correspondents will be printed in full unless otherwise requested. All correspondence should be as brief as is consistent with clearness. THE ELECTRICAL WORLD *assumes no responsibility for the opinions expressed by correspondents.*

[39 and 40.] Various substances are used as filaments in incandescent lamps. The Edison lamp has a thin strip of carbonized bamboo, the Swan a cotton thread parchmentized in sulphuric acid and afterward carbonized; the Lane-Fox prepared and carbonized vegetable fibres, and the Sawyer Man a carbonized paper filament. The filaments are generally placed upon a shape or frame of carbon, wood or other substance, surrounded with some such substance as charcoal, finely powdered, packed in an iron box carefully luted with fireclay and heated to a high temperature. C. D.

[53.] The rate per car mile to charge an electric railway would depend on data not given in the question. Carefully compute the power required by the cars, then the loss in the motors and wires; the sum will give the necessary current output at the dynamo brushes. Calculate all the extra expense and depreciation per day of producing this current, divide by the car miles, and you have the minimum rate, which may be in the neighborhood of two cents.
C. A. R.

[54.] Taking the simple case of a single coil on the armature of a bipolar motor, there are two attractions and two repulsions in every revolution, acting as a turning moment on that section, due to the two poles of the machine. In the case of a multipolar machine, in one revolution there are twice as many attractions and repulsions as there are poles to the machine, consequently, we may say roughly, that the speed varies inversely as the number of poles. The lighter weight is due to the fact that the distribution of the field magnets, and the directions of the lines of force is such, that a much less massive yoke is used than in bipolar machines.
P. E. C.

[55.] Probably a compound of shellac and ground mica would answer the purpose. C. H.

[56.] Twenty cents per 1,000 watt hours is equivalent to $2.00 per 1,000 feet of gas. F. A. K.

[60.] There is probably a loose connection in your armature, where the section terminals are connected to the commutator segments. I have often met cases like this, where in testing out the armature it will not show an open circuit, but the vibrations of high speed armatures cause the contact to open and close. Such a sparking will also ensue if the connections to the commutator are wrong. P. E. C.

[62.] If the lamps are for 110 volts or thereabouts, a variation in the voltage of one or two per cent. should not cause a perceptible diminution in the brilliancy of the lamps. If such is the case there is probably something wrong with the lamps. If lamps are of low voltage, then such a state of affairs might exist, due to variation in load or speed, or both. P. E. C.

[63.] Two 200-volt 20-ampère dynamos connected in series would increase the E. M. F. to 400 volts with the same current in both mains and armature. F. A. K.

[64.] I do not see how you can connect two motors in "multiple series;" they must be either connected in multiple or in series, for it requires at least four to connect in multiple series. If connected in series you could take the 400 volts through the motors as the joint resistance would be sufficient, but you would not have an increased current, as that would remain the same, 20 ampères.
F. A. K.

News of the Week.

THE TELEGRAPH.

To Place Its Wires Underground.—The Western Union Telegraph Company contemplates, it is stated, placing its wires underground in the city of Syracuse, N. Y. A large amount of money will be used in the work, which will be extensive, inasmuch as Syracuse is an important point for the Western Union, being a central point of radiation of many lines north, east, south and west.

The Western Union in Denver.—An interesting temporary change in the Western Union Telegraph office in Denver, Colo., which may be made permanent, was made soon after the storm, which a few weeks since devastated lines in the West. The Wheatstone system of repeating, in operation at Kansas City and Cheyenne, has been concentrated in Denver. The process of the Wheatstone system is a rapid one and necessitates a special corps of operators. The Cheyenne office has been moved to Denver with four operators, and six more have been brought on from Kansas City. Some of these operators have reached a high degree of experness, and one young lady who is employed at translating the slips of paper which come out of the Wheatstone machine into typewritten copies is regarded as the most skillful and rapid operator in the United States. She is able to copy 450 to 500 messages per day, while the average is said to be about 250 or 300. At present all messages between the East and the coast are relayed in Denver by the Wheatstone system.

New Postal Telegraph Lines.—The Postal Telegraph Company, it is stated, has decided on important extensions to its lines from Denver, Colo., and two large extensions will be made at once. One will strike out directly west, touching Leadville, Aspen, Glenwood Springs, Grand Junction, and joining at Salt Lake the line now being brought eastward from Portland, Ore., through Montana. That will give a line direct from Denver to the northwest coast. Another line will be constructed southward from Denver through Trinidad to Albuquerque, following the Atchison, Topeka & Santa Fe to its connection with the Southern Pacific. Then it will go with that road westward to Los Angeles. The company has a line already to that point through San Francisco from Portland. The construction of these lines will give the Postal company a complete circle, embracing the best of all the Western territory. Other smaller extensions are in contemplation. During the past 12 years the company has touched the greater part of the United States, and is continually reaching out for new territory. In the Eastern States it has paralleled the Western Union in many cases, as far as the principal points are concerned. Through the Mackay-Bennett cable to London it reaches foreign points. Most of the cities of the South it reaches, the State of Texas being almost the only one in which it has no wires. A wire along the Canadian Pacific connects the East with the Pacific coast. With the completion of the new lines the company will have greatly increased facilities, and an opening into valuable territory.

THE TELEPHONE.

The Bell Telephone Company has, it is stated, acquired three important patents on contrivances which, it is claimed, are of great value to the telephone. They are on what is known as the carbon contact, and will be issued on May 3 to Thomas A. Edison, who has assigned them to the Western Union Telegraph Company, from whose hands they have passed to the Bell company.

Long distance telephone connection between Milwaukee and New York will be complete within a year, it has been announced by Secretary McLeod, of the Wisconsin Telephone Company. The long distance telephone lines of the American Telephone and Telegraph Company are now completed as far west of New York as Cuyahoga Falls, O. The material for building the line into Chicago is now being laid down, and will be completed before the World's Fair is opened. As soon as the New York line is extended to Chicago the Milwaukee circuit will be connected with it.

THE ELECTRIC LIGHT.

The Electrical Construction Company, of Chicago, has been granted a franchise by the City Council of Kansas City for putting in an electrical plant, and it is stated the company will put in a plant for lighting and power purposes.

Pittsburgh, Pa.—The electric light plant which Solomon & Reuben contemplate placing in their gigantic structure to be erected here will consist of four dynamos, generating electricity to supply 100 2,000-c. p. arc lights and 1,500-c. p. incandescent lights.

Racine, Wis.—Racine is to have electricity at last. Tenders for the erection of the plant and the placing of thirty arc and twenty incandescent lamps in position will be opened next Wednesday. The cost is expected to be $14,000. The plant will be run by the corporation itself.

Montreal, Can.—The chairman of committee on lights will receive proposals from any party or parties willing to manufacture and supply the light to the city, as the present company's contract expires in August. The city is now paying $80 per lamp, which the present company wants increased to $90.

A complete electric light installation is to be put in the New Equitable building at Des Moines, Ia. Contracts have just been placed with the Chicago office of the Pond Engineering Company for one 25 and one 60 h. p. Armington & Sims engine, with foundation boxes. The Pond company is also to deliver and erect these engines in Des Moines, with pipe connections and foundations.

The National Electric Manufacturing Company recently installed a National plant at Paragould, Ark., through Mr. W. E. Bailey, its Southern representative. The citizens of Paragould are enthusiastic in their appreciation of the advantages of electric lighting and the successful working of the National system, which was put in under the superintendence of Mr. E. Overman, of the National Electric Manufacturing Company.

An Important Contract for an incandescent electric lighting plant for the new and projected buildings, 19 in all, for Kings County (N. Y.) county farm at St. Johnland, has been let by the board of supervisors of Kings county to the Thomson-Houston Electric Company. Only two bids were received. The amount of the Thomson-Houston bid is $265 487. Only about half of the buildings have been constructed and it is the intention to have only enough of the plant installed to light these pending the completion of the rest.

Hornellsville, N. Y.—The contract for the equipping of the Hornellsville Electric Railway has been given to the Edison General Electric Company, at Pittsburgh, Pa. The road is to be three and one-half miles long, equipped with 56-pound girder rails, and is to have five 18-foot Brill cars with five open trailers, and cars are to be equipped with the new Edison single reduction mo-

ors. The power will be placed in the present Edison station. The road is to be in operation by July 1, and is to have the very best class of material throughout.

Hammond, Ind.—Besides having the promise of electric car service in the future the people of Hammond are promised an improved light service. The present electric light plant has just been sold by M. M. Towle to the Northern Lighting Company, of Chicago, which has been incorporated with a capital stock of $30,000, and is headed by W. W. Hutchinson. A. C. Barnes is secretary of the company and Louis Lusk is manager. The present plant at Hammond includes 16 miles of wire and poles and has 100 arc and 800 incandescent lamps. The entire plant is to be refitted and extended.

The Onondaga Electrical Company, of Syracuse, N. Y., has closed a contract for its electrical apparatus. The Edison General Electric Company is to furnish the incandescent apparatus, and the Fort Wayne Electric Company the arc light and power machinery. It is expected that before Aug. 1 the company will be supplying light and power. The arc lights will be made from 80-light machines, of which four will probably be put in at first. These lights will be of 2,000 c. p. each. Of incandescent lights two kinds will be furnished—the Slattery alternating current system and the Edison light. Apparatus for 2,500 of the Slattery and 4,000 of the Edison lights will be put in. In the power department there will be capacity for at least 500 h. p. The steam plant will start off with a capacity of about 1,000 h. p. There will be one Corliss engine of 500 h. p. and two of 250 h. p. each. The boilers will probably have a capacity of 1,200 h. p. The capital stock of the company is $250,000. The plans as adopted call for the expenditure of at least $150,000 before the plant can be operated.

THE ELECTRIC RAILWAY.

Inspecting Trolley Systems.—Director Beitler and David R. Walker, Chief of the Electrical Bureau of Philadelphia, have been inspecting electric street railway systems in Rochester, Buffalo Cleveland, Pittsburgh, Boston and other cities where the trolley system is in successful operation.

New Bedford, Mass.—J. Irving, president of the New York Equipment Company, is at the head of a syndicate which has obtained a majority of the stock of the Union Street Railway Company of this city. A majority of the stock has been already deposited in the bank, and until July 1 is given to the rest of the stockholders to deposit, when the syndicate will take it. The idea of the purchasers is to equip all the roads with electrical appliances. It will cost $250,000 or $300,000, it is estimated, to put the roads in good condition.

The Interstate Electric Railway, which is being built between North Attleboro, Mass., and Bullock's Point, R. I., will be pushed rapidly to completion. About one-third of the 42 miles of track has been completed. The American Electrical Works of Providence, R. I., has an order for 60 miles of heavy feeder wire and 42 miles of trolley wire for the line. Contracts for generators and car equipments have also been made. Negotiations are in progress for the purchase of a power plant. President Daggett states that the road will be all ready for traffic to Bullock's Point before the middle of August.

The Philadelphia Trolley Ordinance.—The new trolley ordinance of the Traction company offered in City Councils has been referred by the joint committees on law and railroads to a sub committee for consultation with the city solicitor and director of public safety to be reported on within two weeks. John C. Bullitt has sent a written opinion to Dilwyn Wistar, chairman of the union committee, giving at length his reasons for believing the seven trolley ordinances of March 31 to be invalid, and expressing the opinion that it is by no means certain that the proposed agreement which the Traction company has offered to sign could be enforced.

The Trolley in Brooklyn.—The New York State Board of Railroad Commissioners on April 21 granted the application of the Atlantic Avenue and Brooklyn Railroad Company to change the motive power on their system from horses to the electric overhead system. The route on which the trolley will be used traverses the heart of the city and part of the wires will be strung under the "L" structures. The work of stringing the wires will be begun at once. The only system using trolley wires in this vicinity in the past has been the East New York & Jamaica Road. Applications of several other companies to use trolley wires have already been made and are under consideration.

Electricity in Tunnels.—The Belt Railroad Company, of Baltimore, Md., has received an offer from the Thomson-Houston Electric Company to thoroughly equip its tunnel for the running of trains through it by electricity, without the expenditure of any money on the part of the railroad company, and to give the latter the free use of the plant for six months, provided that if the experiment shall prove to be what the Thomson-Houston people claim the railroad company shall take the plant at an agreed price. The Belt Railroad Company will consider the offer, and if accepted the difficulty of ventilating the tunnel will be obviated, as there will be no smoke to be gotten rid of.

A projected electric railway enterprise from Sanford, Me., to Kennebunk is in contemplation. Surveys of the route have been made by the construction companies with a view to bidding for the contract. It is estimated the road can be built for a little over $100,000, and about 60 per cent. of this stock is already assured, taken almost entirely in Kennebunk, and the balance, it is expected, will be taken by the citizens of Springvale and Sanford. The road will deliver some 30,000 tons of freight per year, and in addition will have a large passenger traffic. The 18 miles of railroad proposed would open up this section of the country, and would put the people in direct communication with Boston, as by this route they could go to Boston in the morning, have five or six hours time there, and return to Sanford the same night.

The Short Electric Railway Company has just placed some important orders in the New England States. Mr. Edward J. Wessels, of the New York office of the company, has recently secured orders from the Norwich Street Railway Company, the New Haven and West Haven Horse Railway Company, of New Haven, Conn., and from the Natick Street Railway Company, of Natick, Mass., the latter road already operating three Thomson-Houston motor cars. The New Haven and West Haven Horse Railway will have 19 single equipments of 25-h. p. single reduction motors and seven double equipments of the same type. The order for the engines and generators for this road has been placed with Westinghouse, Church, Kerr & Co., who will supply three of their large sized direct connected engine and dynamo units. Norwich, Conn., will have fifteen 25-h. p. single reduction motors. The entire order will be filled immediately, and it is expected that the three roads will be using the apparatus early in June.

The Chicago & St. Louis Electric Railroad.—The preliminary survey of the route of this road has been completed. The plans of the company and the details in regard to its contemplated construction were given in THE ELECTRICAL WORLD of Feb. 20. An interesting feature in regard to the survey just completed is the fact that the last stake marking the surveyors' course was planted within less than 100 feet of the Chicago Shot Tower, which was made the objective point in starting. This is a very close calculation considering the fact that the variation of one-sixteenth of an inch in starting would have thrown the survey 32 miles wide of the objective point. The feat of surveying just accomplished is something seldom before undertaken and is known as an air line survey, and the engineer in charge undertook to go in a direct line from a given point to a given point. Three lines were run. Two of these are considered most excellent, for the reason that they do not strike through either a graveyard or a town, and but three or four houses in the whole 252 miles of the course, though they run within a few hundred feet of a number of large towns. Of the 252 miles there are only about four miles which will need grading to any amount. The company has been guaranteed the right of way along nearly the whole route, which is 31 miles shorter than the shortest steam railroad. As soon as the line is decided upon the company will proceed to put down the first five-mile section of track.

PERSONALS.

Mr. H. P. Frist, superintendent of the Delaware Hard Fibre Company, Wilmington, Del., severed his connection with the above company on April 16.

Mr. Charles Patterson Bruch was united in marriage on the evening of April 20 to Miss Elizabeth Dean Lowerre, daughter of Mr. Thomas H. Lowerre, Jr., at the bride's residence, 45 East Sixty-seventh street, New York. Among those present at the reception were Dr. Norvin Green and Mr. and Mrs. Thomas A. Edison.

Eugene H. Cowles, of Cleveland, O., died on April 21 at El Paso, Tex., where he had gone for his health. Mr. Cowles was 38 years old. He was a director and secretary of the *Leader* Printing Company, and manager of the Cowles Electric Smelting and Aluminium Company, of Lockport, N. Y. Together with his brother, A. H. Cowles, he invented the process of extracting aluminium from the ore by electrical heating, marking a distinct step in metallurgy.

MISCELLANEOUS NOTES.

Washington, D. C.—The resolution requesting the Secretary of Agriculture to obtain information concerning the use of electricity as a power to drive farm machinery and implements and on the propagation and growth of plants in foreign countries has been agreed to by the Senate.

An electric welded projectile, manufactured at Lynn, Mass., was recently successfully tested at the naval proving ground at Indian Head, on the Potomac. Two plates, one of which was a 2½-inch steel deck plate and the other a 3-inch iron armor plate, were penetrated by the missiles from a 4-inch rapid-fire gun.

To Have an Electrical Exhibit.—It has been decided to make a complete electrical exhibit one of the features of the Buffalo (N. Y.) Exposition, which will be held in August of this year. One of the novelties suggested is a miniature of the Niagara Falls tunnel, showing how the tunnel is to be utilized in the transmission of power.

The American Art Journal of April 16 is a souvenir number of 68 pages, in celebration of the paper's thirtieth birthday and the completion of Editor Wm. M. Thoms' twenty-fifth year of consecutive work on the *Journal*. It is a very creditable number and commemorates two events that seldom occur in connection with the same paper. Mr. Thoms is to be congratulated.

The Anaconda Mining Company, at Fremont, Colo., has selected an electric drill of the latest pattern, which will be placed in operation on the tunnel at the foot of Gold Hill. The Rose Maud, Anaconda and Excelsior lodes will also be connected and worked by electricity. The company at present is shipping on an average about one car a day, which is netting $1,000 a car at Florissant. It is expected by the company that with the new drill it will be able to double the shipments and complete the tunnel a distance of 1,000 feet within 90 days.

An Important Electric Plant Contract.—The Thomson-Houston Electric Company has contracted to place a $150,000 electrical plant at the Eastern opening of the Atlantic-Pacific Railway Tunnel Company's tunnel. This tunnel, when completed, will reduce the distance to Denver by almost 300 miles. The electric power from the plant will be used in drilling and lighting, it is stated, as well as for motive power in propelling the cars which carry the ore and rock from the tunnel. The plant just contracted for is one of the most complete and expensive electrical outfits ever manufactured in the United States.

Electricity for Ginning Cotton.—The first successful application of electricity for ginning cotton in the history of the world was made at Auburn, Ala., recently, at the Agricultural and Mechanical College of Alabama. The experiment was made for the purpose of illustrating the transmission of power by electricity, and was conducted by Prof. A. F. McKissick and the class of electrical engineering of the college. The motor at the Station farm was furnished with current from a generator in the college laboratory, some 5,000 feet distant, and ginned cotton and ground corn with as much ease as the 10 h. p engine formerly used. It is probable that the electric motor has a large field in this kind of work, especially as it offers such immunity from fire, a very important point in the production of cotton.

Industrial and Trade Notes.

F. M. Dampman, of Philadelphia has recently acquired the agency for Philadelphia of the well known Duro Anti-Friction Graphite.

The Eclipse Clutch Works, of Beloit, Wis., have secured the contract for the entire equipment of the new station of the St. Joe and Benton Harbor (Mich.) Electric Light and Railway Company, and will install a pair of 250 h. p. Williams Eclipse compound condensing engines and all the transmission machinery.

The Electrical Supply Company, of Chicago, has just issued a very attractive catalogue containing 500 pages of handsomely illustrated matter. Besides a complete list of supplies for electric light, railway, power and mining installations, there are formulæ, tables and other information of use to electrical men. It is a very creditable publication.

The Detroit Electrical Works has been awarded the contract for the electrical equipment of the Sioux City & Leeds Street Railway, of Sioux City, Ia. This equipment consists of the overhead construction and five 40-h. p. equipments with car bodies, trucks, etc., complete. This contract was only awarded after an extensive investigation by the officers of the road of all the leading systems.

The Otto Gas Engine.—The following appeared in a recent issue of the *Industrial World*: "It is sometimes said that scientific men have never invented anything, but this is not true of Dr. Otto who is known all over the civilized world as the inventor of the first economically and commercially successful gas engine." Schleicher, Schumm & Co., of Philadelphia, are engineers and builders of this engine.

Campbell & Zell Company, of Baltimore, Md., proprietors of the Enterprise Iron Works, have just been given an important contract for 750 h. p. Zell boilers for the Central Railroad (electric) and 1,400 h. p. Zell boilers for the Bowie cable lines in that city. The Zell boilers manufactured by this company are extensively used, and the Enterprise Iron Works have every facility for turning out first class work.

The Ball Engine Company, of Erie, Pa., recently received the following letter from Mr. C. E. Peers, president of the Warrenton (Mo.) Electric Company: "We started the engine purchased from you for our electric plant last night, and the way it moved off was beautiful to behold. It is certainly a very fine and powerful piece of machinery. No vibration, no noise—in fact and in short it is perfect in every part and way. The satisfaction it gives is a pleasure to us and it must be gratifying to you."

The Lunkenheimer Brass Manufacturing Company, of Cincinnati, O., is preparing for the World's Fair a most elaborate display of its popular specialties in valves, sight feed lubricators, oil and grease cups, etc., and will also exhibit a complete line of brass and iron goods, besides some novelties in steam whistles and sight feed lubricators. It reports business exceedingly brisk, being crowded with orders for its numerous specialties and receiving large contracts for special work for United States cruisers.

The Shawmut Fuse Wire Company, 85 Water street, Boston, Mass., has purchased of the Massachusetts Electrical Engineering Company its present fuse wire business, including all machinery, apparatus, etc., used in the manufacture of fuse wire and links, and hereafter will devote its interests exclusively to the manufacture and sale of the different forms of fuses used for electric lighting, street railway and telephone purposes. The company has arranged with the Massachusetts Electrical Engineering Company to test its entire product under the exact conditions in which it is used in practice, thus assuring a thoroughly reliable fuse.

C. H. W. Copeland, Eastern agent of the John T. Noye Manufacturing Company, of Buffalo, N. Y., manufacturers of the Rice automatic engine, has just completed the construction of a steam plant for the New York Aristotype Manufacturing Company, of Bloomfield, N. Y. This plant will consist of a 40-h. p. boiler and a 25-h. p. Rice automatic engine, driving an Excelsior dynamo for light and power in their factory, also a complete steam plant consisting of a 100-h. p. Rice automatic engine for the Port Henry Electric Light and Power Company, and a 250-h. p. plant for the Portland Electric Light and Power Company, of Portland, Conn.

The Massachusetts Electrical Engineering Company has sold all material and machinery used in the manufacture of fuse wire, together with the good will of the business, to the Shawmut Fuse Wire Company, of Boston. This company has been organized expressly for the purpose of manufacturing fuse wire and links of the highest grade, and will have every facility for filling orders in a prompt and satisfactory manner. All the wire and links which it manufactures will be tested, as heretofore, at the laboratory of the Massachusetts Electrical Engineering Company, and a signed certificate of test will accompany each spool of wire and lot of links sold.

The Short Electric Railway Company is now shipping to the Bangkok Tramways Company, Siam, the entire installation for the first electric tramway in that country. The road is six miles long and practically level, but crosses fourteen of the many canal bridges in Bangkok. The gauge is 30 inches. The poles and all wooden parts will be of teakwood. Twenty generators, two complete steam plants, six car equipments and extra parts to last for six months make up the equipment. The order is the result of the visit to this country of Mr. Aage Westenholz, a leading engineer in Siam, who made a thorough examination of the various electric railway systems in this country and Europe.

The Brown & Sharpe Manufacturing Company, of Providence, R. I., expects to have the new three story extension of its No. 3 building ready for use in August or September. The foundations for this building were laid last year. The size of the new building is 166 × 56. It will be practically fireproof and will be used for storing patterns, 40,000 or more of which are in use. Space will be reserved on the first floor for molding sand, four bins being provided for the purpose, each 12 × 24 feet and 10 feet in depth, with a total capacity of 600 tons. The new building will be a model of convenience for the purpose intended and will give added facilities for the constantly increasing business of the company.

The Railway Equipment Company is the title of a new company which has recently been organized in Chicago for the purpose of manufacturing and dealing in electric railway supplies for use on all systems. Mr. W. R. Mason, formerly general manager of the Electric Merchandise Company, is general manager of the new company. Mr. Mason is well and favorably known in street railway circles, and with his long and practical experience in all branches of electrical business the requirements of the street railway trade will be cared for successfully, and patrons may rest assured that their interests will be carefully looked after. The company has opened temporary offices at 617 and 619 Pullman Building. Everything needed for the complete equipment and maintenance of electric roads will be carried in stock.

The Electric Appliance Company, of Chicago, is meeting with considerable success, it is stated, in the sale of canvas jacket wire and flexible conduit, and has taken several nice orders for both. The trade generally are beginning to recognize the merits of the flexible conduit on account of the ease with which it can be installed. It is also being used largely as a substitute for hard rubber tube in running wires through outside walls and partitions. The peculiar canvas weave used in covering both the wire and the conduit is very effective, and produces an insulation, it is claimed, that is well-nigh waterproof as well as weatherproof. The insulation is made of the same material used in making the heaviest tent canvas, which it is well known is thoroughly waterproof. The waterproof qualities of the wire, however, are largely increased by a liberal application of compound, which produces also a superior insulation.

Business Notices.

Molds for Casting Zinc, Lead, Carbon, Etc.—Every facility and experience for making these specialties. Address Homer Brooke, 44 Barclay street, New York.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

35-light, 2,000-c. p. American arc dynamo, in good condition, for sale at a bargain; also 750-light Westinghouse alternator, with station appliances. Address E. T. Pardee, 10 Butler Building, Syracuse, N. Y.

The King Annunciator, made by Partrick & Carter Co., of Philadelphia, is one of the most successful specialties ever introduced by that house. It fills all the requirements of a low-priced and perfect working annunciator, and is just the thing for contract work, where the finely finished instruments are not demanded. See advertisement in this week's issue.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED MARCH 19, 1892.

472,982. Conduit and Trolley for Electric Railway Systems; Charles W. Carll and James W. Phillips, Trenton, N. J. Application filed Feb. 19, 1891. A conduit for electric railways, consisting of a main body portion having re-entering flanges at its upper portion, chairs for supporting and sustaining the main body portion, said chairs being provided with a basal flange, and outwardly projecting top flanges, ties or sleepers, to which the basal flange is connected, cross braces for connecting the chair to the track-stringers, and a covering-plate secured to the flanges, said covering plate being provided with angle-pieces separated to form the conduit slot.

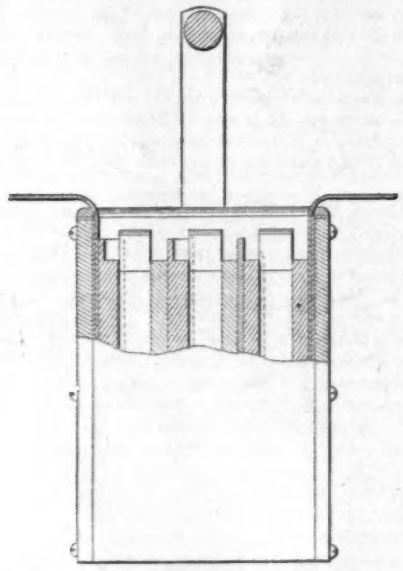
472,983. Signaling System; Henry A. Chase, Boston, Mass. Application filed Nov. 6, 1891. In a system for transmitting signals, the combination of an electric circuit, a receiving instrument located therein, and a signal apparatus or box included in said circuit and provided with a signal-transmitting mechanism constructed and arranged to transmit to the receiving instrument the same complete signal without additions thereto, subtractions therefrom, or repetitions thereof at different speeds at the will of the operator, whereby two different and distinct purposes may be indicated by the same complete signal.

473,003. Heating and Welding by Electricity; Henry Howard, Halesowen, near Birmingham, England Application filed Oct. 20, 1891. An apparatus for heating or welding by the electric arc; in which the work forms one pole, comprising a pencil forming the other pole, a generator of electricity, circuit connections between the pencil and the generator, and between the generator and the work and a resistance interposed in the circuit and arranged in proximity to the work, but at a suitable distance therefrom to avoid short circuiting and adapted to heat the work by radiation while being heated by the electric arc, and means for moving the pencil over the work.

473,004. Conduit for Electric Wires; Charles H. Wilson, Chicago, Ill. Application filed Sept. 19, 1889. The combination, with a conduit or subway having two ducts separated by a horizontal partition and a lateral pipe extending therefrom, of a T connection at the junction of said subway and lateral pipe, the main portions of the said T being partitionless, or having the full bore of the conduit pipe.

473,024. District Telegraph Box; Charles Selden, of Baltimore, Md. Application filed June 15, 1885. In a district telegraph system, the combination, with signal boxes having circuit closing and breaking contact spring and connections in the line and ground circuits, and of an indicator having two magnet coils connected respectively to the ground and line circuits from the box.

473,045. Lighting Arrester; Montraville M. Wood, Chicago, Ill. Application filed June 20, 1891. In a lightning arrester, the combination of a ground wire with a wire leading to the line and a connecting circuit from line to ground, consisting in part of a substance of high resistance and a substance of low resistance, the two opposed to each other and one substantially surrounding the other.



No. 473,146.—Secondary Battery.

473,061. Electric Lock; Charles H. Crockett and Chancellor C. Allen, of Boston, Mass. Application filed May 5, 1888. The combination of a lock provided with two bolts, with an electromagnet and its armature co-operating with one of said bolts and a knob co-operating with the other of said bolts, the said magnet-controlled bolt having clearance between it and the striker plate when the knob-controlled bolt is engaged with the striker plate.

473,076. Electric Arc Lamp; Octave Patin, of Paris, France. Application filed April 11, 1891. In an arc lamp, in combination with the carbon holders, a solenoid, a core movable therein, and when unattracted holding the carbons apart, a dashpot for taking up the shock of the movement of the core, a cord attached to the upper end of said core, a shaft, a pulley on said shaft, over which the cord passes, a spring attached to one end of the cord and to the frame to form a brake on the pulley, and connections between the shaft and the carbon carrier.

473,077. Armature Core for Electric Motors; David Pepper, Jr., Philadelphia, Pa. Application filed July 24, 1891. An armature core for electric motors or dynamos, formed of sections having at their ends tongues and inclosed recesses adapted to fit together, in combination with an interlocking device arranged to prevent independent movements of the sections when united to or from their common centre.

473,078. Armature Ring; David Pepper, Jr., Philadelphia Pa. Application filed Dec. 3, 1891. In an armature ring, the combination of core sections meeting end to end, and each having near its ends grooves formed in the inner face of the sections, with a spider and arms having fingers formed to enter the grooves or abutting sections, and lock the sections together.

473,089. Testing Apparatus for Trunk Lines of Telephone Exchanges; Charles E Scribner, Chicago, Ill. Application filed March 13, 1885. The combination, with two or more multiple switchboards, of trunk lines and their spring jacks, local circuits, one for each trunk line, a circuit closer operated by the movement of the springs of the different spring jacks to close the local circuit of any given line when a connection is made therewith, a reed or vibrator included in the battery wire common to all of said local circuits, test terminals or studs connected with the local circuits, one with each local circuit at each board, said test terminals being placed near one another in line, and testing apparatus at each board to determine whether any given test terminal is connected with the battery and reed or vibrator.

473,121. Electrical Annunciator; Thomas W. Lane, Boston Mass. Application filed Dec. 15, 1890. In an electrical annunciator, in combination with a gravity-signal tag and a magnet properly arranged to operate the same, an electrical set back composed of a magnet, an armature having a spring connection, a supporting post therefor, and a proper locking device.

473,123. Machine for Making Insulated Magnetic Coils; Charles E. Lips, Syracuse, N. Y. Application filed Oct. 3, 1890. In a machine for making insulated magnetic coils, the combination, with the winding shaft and means for retaining it, of a tool comprising a shank, a stud upon its outer end, and a bevel-edged shearing cutter on the stud, and a roller on the same stud in front of the cutter, and a tool post carrying said tool.

473,132. Electric Switch; Francis H Soden, Chicago, Ill. An electric switch comprising a base provided with contacts and a universally swinging yoke, having its arms provided with contacts and supported upon the base by universal joints, the yoke being articulated so as to permit its arms, while maintaining a condition of parallelism with one another, to swing about their respectively allotted centres.

473,133. Electro-Therapeutic Heating Pad; Francis H. Soden, Chicago, Ill. Application filed Sept. 1, 1891. A therapeutic electric heating-pad comprising a heating-conductor confined within a flexible sheet or sheets.

473,134. Electric Switch; Francis H. Soden, Chicago, Ill. Application filed Oct. 26, 1891. In an electric switch, a single switch-arm pivotally held by a universally jointed swivel upon a base provided with contacts and provided at points along its length with contact portions insulated from one another.

473,146. Secondary Battery; Harry E. Dey, New York. Application filed Sept. 10, 1890. A negative plate for secondary batteries, composed of finely divided or spongy lead with compacted and projecting edges. (See illustration.)

473,147. Secondary Battery; Harry E. Dey, New York. Application filed Sept. 17, 1890. The combination, in a secondary battery, with the positive and negative plates of the same, of metallic partition plates interposed between contiguous active plates and provided with thickened or flanged edges, and packing between the edges of the partition plates.

No. 473,353.—Electric Cable.

473,158. Hanger for Electric Wires; Thomas Imeson, Lewis D. Tibbets and Charles L. F. Kellogg, Seattle, Wash. Application filed Feb. 2, 1892. An electro-conductor or trolley-wire support consisting of interlocking jaws in combination with a pivot plate.

473,174. Electric Indicating System and Instrument; Henry Jansen Haight, New York. Application filed Dec. 15, 1891. A plurality of groups of electric indicating instruments, the indicating instruments in one group corresponding with the instruments in the other group or groups, in combination with two multiple circuit closers each having a plurality of electrodes, and a circuit-closing arm capable of a step-by-step movement, whereby it is brought successively into contact with and dwells upon each of the electrodes, each of the electrodes of one of said multiple circuit closers being connected in multiple with the corresponding electric indicating instrument in each of said groups, and each of the electrodes of the other multiple circuit closer being connected in multiple with all of the indicating instruments in one of said groups.

473,190. Railway-Signal; Uriah S. Jackson, Ossipee, N. H. Application filed Oct. 21, 1891. This invention embraces the comb of a signal-wheel having an auxiliary disc which is adapted to operate a system of levers, a signal board having a notched disc acted upon by the armatures of an electromagnet, and a current closer controlled by said levers.

473,195. Commutator Brush; George Meyer, Indianapolis, Ind. Application filed June 6, 1891. The combination in a commutator brush of a holder provided with a series of perforations and a series of corresponding sockets alongside said perforations, standards secured in said sockets, pencils forming the contact points of the brush mounted to move in the perforations, a yoke secured to each of said pencils and mounted to slide on the adjacent standard, and a spring interposed between the yoke and a suitable rest on the standard.

473,208. Incandescent Electric Lamp; Augustus C. Carey, of Lake Pleasant, Mass. Application filed Dec. 1, 1891. In an incandescent electric lamp, a globe, leading-in wires, and the inwardly projecting holder for the leading-in wires, combined with couplings of flexible material connected with said leading-in wires, conductors also connected with said couplings at one end, and depending thence and couplings applied at the other ends of said depending conductors, and the carbon having its ends secured in said last named couplings.

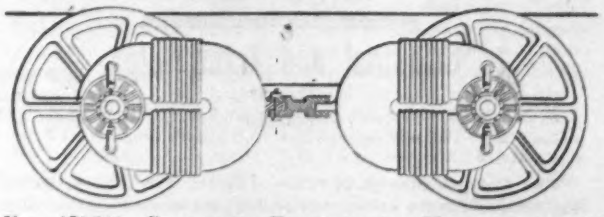
473,209. Rheostat; Augustus C. Carey, Lake Pleasant, Mass. Application filed Jan. 27, 1892. A carrier containing electric resistances, any number of which may be included in circuit or all excluded, leading in or leading out conductors applied to said carrier and movable with it, a stem upon which said carrier may be revolved, and stationary caps containing appropriate contacts for co-operation with the carrier.

473,228. Electric Switch; Edward H. Johnson, New York. Application filed Aug. 25, 1891. The combination, in a switch, of two rigid members corresponding to the jaws of a vise, one of which members is movable repeatedly in the same direction in making and breaking circuit contacts carried on the two adjacent sides of the rigid members, which contacts when the circuit is closed are held in contact between the rigid members, means for separating the contacts, and a spring for throwing one member with its contents forward.

473,253. Converter System for Electric Railways; Mark W. Dewey, Syracuse, N. Y. Application filed June 25, 1889. In an electric induction railway, a source of irregular or alternating currents, a conductor extending therefrom, a series of coils distributed apart along the way and connected with the conductor, a vehicle, a conductor on the vehicle in suitable, inductional relation to the coils and a translating device connected with the latter conductor.

473,256. Telephone-Receiver; Edwin Charles Hess, of Camden, N. J. Application filed July 1, 1891. The combination, in a telephone receiver, of the main standard receiver, to which the main wires are attached, an arm pivoted to the main receiver, and a second receiver carried at the opposite end of said arm, with wires passing through the arm from the main wires and attached to the opposite receiver, so that both instruments will be in circuit without disturbing the general arrangement of the standard receiver.

473,267. Electric Cable; William Henry Sawyer, Providence, R. I. Application filed Oct. 27, 1891. An electric cable formed of a number of sections, each composed of a series of wires interbraided with fibrous material into tubular form to provide a base or core for the reception of a successive series of wires similarly braided thereon, the wires of the first series being braided on in opposite direction to that of the successive series and all the wires being approximately equidistant.



No. 473,348.—Gearless Propelling Mechanism for Electric Railway Cars.

473,282. Cut-Off for Electrical Machines; James P. Woolley, Simcoe, Canada. Application filed Nov. 23, 1891. The combination, with an electromagnet, of a weight normally suspended under and supported by said magnet, and a cord passing over pulleys and connected to the circuit-breaker.

473,283. Electric Arc Lamp; Thomas E. Adams, Cleveland, O. Application filed July 8, 1890. In an electric arc lamp a sectional friction clutch provided with a narrow and elongated wearing surface and an adjoining groove for the reception of dirt or dust. (See illustration.)

473,288. Electric Railway Signal; John M. Brasington, Morven, N. C. Application filed July 24, 1891. An electric railway signal comprising a bell arranged in the cab of a locomotive and included in an electric circuit, a contact block mounted on the locomotive and having the wires of the bell connected therewith, a spring-pressed lever to contact with the contact block, a tilting plate to engage the lever and hold it from the contact block, a lever pivoted on the locomotive and to the tilting plate, said lever extending to a point adjacent to a track rail, and a signal post arranged adjacent to a track rail and adapted to engage the lever.

473,351. Electric Cable; William H. Sawyer, Providence R. I. Application filed Oct. 27, 1891. An electric cable composed of a flexible tube or core formed of the two wires of a metallic circuit, coiled spirally together and the wires of one or more metallic circuits interbraided with fibrous material upon said flexible tube or core.

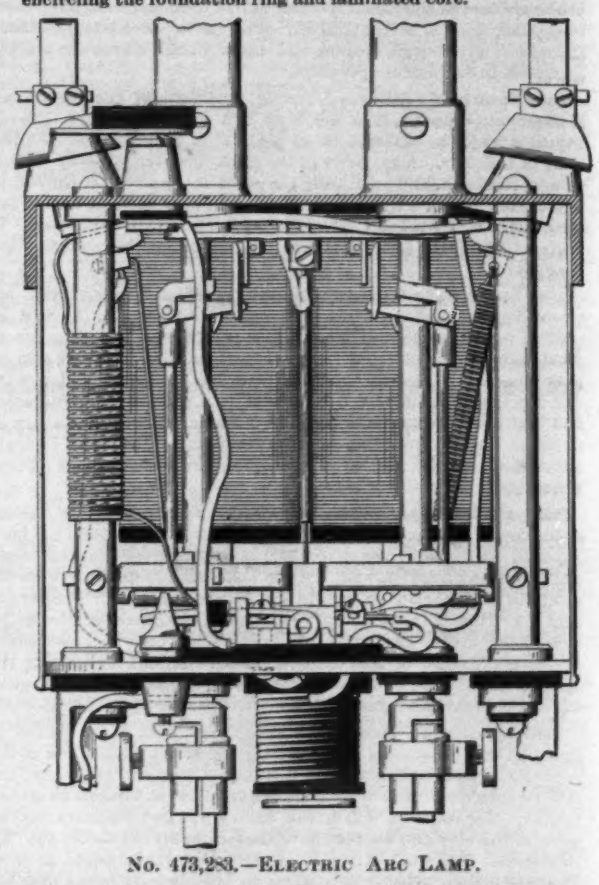
473,352. Electric Cable; William H. Sawyer, Providence, R. I. Application filed Oct. 27, 1891. An electric cable formed of a number of sections grouped together, each section being composed of a series of insulated wires or conductors interbraided with fibrous material into a continuous flat strip or ribbon, which is wound or twisted into a spiral tube having a central air-space, and one or more strips or ribbons similarly constructed being wound upon said spiral tube in reverse directions and the whole enclosed within a lead sheath or other suitable covering.

473,353. Electric Cable; William H. Sawyer, Providence, R. I. Application filed Oct. 27, 1891. An electric cable composed of one or more metallic circuits interbraided with fibrous material into tubular form to provide a central core or foundation and a successive series of metallic circuits similarly interbraided with fibrous material upon said core or foundation, the wires or conductors of each successive series being wound on in a reverse direction and at an increased or decreased angle or pitch to the wires of the core or foundation. (See illustration.)

473,361. Multiple-Arc Railway System; Sidney H. Short, Cleveland, O. Application filed Jan. 8, 1890. The combination, with a generator and two sectional trolley lines or conductors, of a series of feed wires extending from one pole of the generator to and connected with the respective sections of one trolley line, and an automatic cut-out included in each one of said feed-wires at a point near the generator, and a series of feed-wires extending from the other pole of the generator to and connected with the respective sections of the other trolley line.

473,362. Trolley-Switch; Sidney H. Short, Cleveland, O. Application filed Jan. 8, 1890. A trolley-switch comprising a yielding trackway or switch rail, on which the trolley runs, and a stationary flange, with which the trolley engages and serves to automatically shift the yielding trackway or switch-rail.

473,363. Armature for Dynamo-Electric Machines; Sidney H. Short, Cleveland, O. Application filed June 10, 1891. An armature for dynamo-electric machines, comprising a foundation ring grooved circumferentially on its inner periphery and a laminated core, a portion of the folds of which are of less width than that of the foundation ring, and bobbins of insulated wire encircling the foundation ring and laminated core.



No. 473,283.—Electric Arc Lamp.

473,364. Armature for Dynamo-Electric Machines; Sidney H. Short, Cleveland, O. Application filed June 19, 1891. A toothed armature for a dynamo-electrical machine, having two, at least, bobbins to a bobbin-space, and provided with a branch conductor for a commutator connection united at an intermediate place to the bobbin wire by a flat-lying joint which leaves the bobbin wire practically continuous for winding.

473,365. Gearless Motor for Electric Railway Cars; Sidney H. Short, Cleveland, O. Application filed June 24, 1891. In a dynamo-electric machine, the combination, with its field poles, of an open centre armature, armature coils wound thereon, and a metal shell encircling the armature coils, said shell or cylinder being supported in direct contact with the field poles, whereby the latter constitute bearings for the armature.

473,366. Armature for Electric Generators or Motors; Sidney H. Short, Cleveland, O. Application filed June 24, 1891. A ring armature consisting of a laminated core having radial grooves extending through the core from its inner to its outer periphery at each of its sides, each groove being of sufficient size to receive a bobbin, narrow open slots being formed in the sides of the core and communicating with said grooves, said slots being of a width sufficient to allow of the insertion of a single strand of the bobbin, and means for closing the slots after the bobbins have been secured in place.

473,367. Dynamo-Electric Machine; Sidney H. Short, Cleveland, O. Application filed June 24, 1891. A dynamo-electric machine having the armature turning in sliding contact with the field poles.

473,368. Gearless Propelling Mechanism for Electric Railway Cars; Sidney H. Short, Cleveland, O. Application filed July 6, 1891. This invention consists of a propelling mechanism for an electric railway car, comprising, in combination with a driving axle, an armature mounted on said axle and rotating therewith and field magnets provided with journal bearings at the periphery of the armature. (See illustration.)

473,373. Incandescent Electric Lamp Socket; Craig Ritchie Arnold, of Sharon Hill, Pa. Application filed Dec. 17, 1891. The combination of a lamp-holder having a spiral spring consisting of an attached spiral spring constituting a screw-threaded socket for attachment of the lamp and having its turns free or disconnected from one another at the open or socket end, and the lamp having a metal screw contact-terminal formed on or attached to its neck or base and adapted to screw into and out of the said spiral-spring contact.

473,386. Electric Battery; James Edward Emley, of Laredo, Tex. Application filed Jan. 27, 1891. In an electric generator, a receptacle for steam, and means for admitting steam thereto, in combination with electrodes consisting of two parallel discs suspended within said steam receptacle, electrodes of opposite polarity to the aforesaid electrodes arranged between the discs of the first named electrodes, a shaft extending through the said receptacle upon which the latter electrodes are mounted, and means for rotating the shaft.

473,135. Electric Switch; Ernest P. Warner, Chicago, Ill. Application filed Feb. 2, 1889. The combination, with two pairs of springs pressing inwardly, the members of each pair being adjusted to close upon different contact pieces, respectively, of a shifter, said shifter being pivotally mounted between said springs, different contact points at the free ends of the different springs of the two pairs, the springs being of a tension to close thereon when unopposed by the shifter, whereby on rotating the shifter the electrical connections are transferred.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1866—can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.